NASA-TM-110078

Notes and Handouts

NASA
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P-153

from the

SEVENTH

MARS SCIENCE WORKING GROUP

MEETING

(NASA-TM-110078) NOTES AND HANDOUTS FROM THE 7TH MARS SCIENCE WORKING GROUP MEETING (NASA) 153 p

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[illegible] June 17, [illegible], Washington, DC

Notes and Handouts

from the

SEVENTH

MARS SCIENCE WORKING GROUP

MEETING

June 17, 1992; Washington, DC

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SEVENTH MARS SCIENCE WORKING GROUP MEETING

A)
Golombek

NOTES OF THE SEVENTH MARS SCIENCE WORKING GROUP

The seventh meeting of the Mars Science Working Group (MarsSWG) was held in Washington, DC on June 17, 1991. The meeting focused on the MESUR Pathfinder mission. An agenda of the meeting (B) and a list of meeting attendees (C) are included. What follows are some general notes about the meeting.

Wes Huntress provided an overview of the current status of code SL. He discussed the status of the CRAF, Cassini, Galileo, and Mars Observer missions. NASA is currently reevaluating its budget over the next few years with respect to priorities and the likely reductions implied by level funding. Wes Huntress outlined the present political environment that is particularly favorable to small Mars exploration missions. An unusual opportunity exists in which the present administration (including OMB), congress, and NASA upper management are all interested in small Mars exploration missions. In response to this rare opportunity, code SL is looking at a Discovery mission, MESUR Pathfinder, which would offer a FY 94 new start for a primarily engineering verification of MESUR cruise, entry and landing subsystems, which would result in a better MESUR Network mission. Huntress countered the various criticisms brought against the Pathfinder mission, that it is too expensive, that its schedule does not mesh with MESUR Network, and that the money could be better used elsewhere. In addition, preliminary discussions are under way towards purchasing a Mars 94 lander, and equipping it with a few US instruments. These landers are RTG powered and provide an opportunity to obtain new information from the martian surface. Finally, an effort is underway within the US to identify new Discovery class missions (small inexpensive planetary science missions), with a workshop planned for November 1992.

Larry Brace discussed the results of an aeronomy workshop and study team to assess the possibility of low cost Mars aeronomy missions (D). They concluded that an upper atmosphere and dynamics mission using existing instruments from an Earth aeronomy mission could best fill in the gaps in knowledge from planned missions to Mars. They are planning to conduct a small study of this mission and present it at the Discovery Mission Workshop in November 1992.

Tony Spear presented an overview of the MESUR Project activities, with special reference to MESUR Pathfinder (E). Pathfinder is intended to be primarily an engineering demonstration of the cruise through landing functions required for a single MESUR aerocraft to Mars (launched in 1996). A trade is being studied between the cost of making instruments and electronics capable of withstanding high g-loading and the cost of building a vehicle capable of a soft landing. It is expected to be solar powered and to carry a small tethered microrover. Obtaining new science data is a goal (but not a requirement) of the mission. Discussion centered on the agreements made with MARSNET, programmatic arrangements for the microrover and the sensibility of the mission.

John McNamee presented a description of the Pathfinder mission (F). A Delta launch vehicle would send a single free-flying MESUR aerocraft to Mars (spin stabilized and solar pointing). Discussion centered on the benefits of Type II trajectories for communication and solar power and the accuracy and characteristics of potential landing sites.

Dave Lehman presented a status report of MESUR Pathfinder flight system studies (G). Costing information will be gathered on a number of design options that include at their extremes, deceleration by retro rockets during final descent for a soft landing to a harder landing decelerated only by airbags. Work is expected to produce a design for the MESUR Pathfinder flight system by the fall of 1992.

Lonne Lane presented the status of the microrover being developed by JPL, as well as plans for science teams and instruments (H). The microrover development is on schedule for a demonstration in late June. In addition, plans for developing a possible fast-track announcement of opportunity for selection of PI instruments for MESUR Pathfinder was discussed.

Roger Bourke presented the current status of the MESUR/MARSNET coordination activities (I). Differences in the designs of the probes and their method of getting to Mars were discussed as well as agreements and possible implications between the two studies. At present, payloads of the two missions are nearly identical (rather than complementary) and MESUR has the responsibility of getting the MARSNET probes to the vicinity of Mars and helping them communicate with the Earth.

Dave Kaplan presented potential instruments that could be provided by the Office of Exploration for the MESUR Pathfinder mission (J). Work is just beginning to better define particular instruments pertaining to abundance of water and composition of the martian soil, the two topics of greatest interest to code X.

Jacques Blamont presented a couple of proposals for consideration to NASA involving small Mars 94 stations from the Russians (K). The Mars 94 lander is RTG powered and carries practically the same science payload as the MESUR landers. One proposal would have CNES purchase an extra station from the Russians and providing it to NASA at no charge for inclusion in the MESUR Pathfinder launch. Blamont argued that it makes no sense for three different space organizations (NASA, ESA, and the Russians) to be developing three different surface stations with the same payload.

Steve Squyres presented the status of the MESUR Science Definition Team activities (L). Discussion focused on the criteria for acceptance of the MESUR Pathfinder mission and potential instruments to be included on the mission. Also included is a letter on the results of the last meeting (L).

What followed was a general and far reaching discussion of the merits and demerits of a MESUR Pathfinder mission. Concern and alarm were raised at the tightly

A

constrained cost cap for the mission, the lack of science in the mission and the short time in which decisions would have to be made on Pathfinder and their affect on the design of MESUR Network. The value of Pathfinder as a programmatic testbed to do a Discovery class mission and its positive effect on MESUR Network were discussed as benefits. Concern was voiced over the tight deadlines in which the fate of Pathfinder will be decided and the potential of giving the project a little more time and money to work on its development before committing. In general the extra funding for Pathfinder was viewed as having a positive impact on the design and development of the full Network. In general the MarsSWG was supportive of a MESUR Pathfinder study as being a positive programmatic and management test and at the opportunity to explore Mars at an early date.

Lou Freidman showed a videotape of the May 1992 Death Valley tests of the Russian rover being developed for Mars 96.

The MarsSWG meeting closed with a session on the charter and membership of the group, both of which will be modified in the near future. No date for the next meeting was set.

B)

Carr

AGENDA

Mars Science Working Group Meeting

Columbia North Room
Capitol Holiday Inn
Washington, DC

June 17, 1992

8.30 Code SL Status (Huntress)

9.00 Mars Aeronomy Workshop results (Jakosky/Luhman)

9.30 Pathfinder

Pathfinder introduction and summary (Spears)
MESUR Network Update
Pathfinder rationale
Mission success criteria and Objectives
Pathfinder cost estimates

Pathfinder mission analysis (McNamee)

Pathfinder Flight System Trades (Collins)

Microrover Demonstration (Lane)
Pathfinder Microrover and Instruments

Pathfinder Operations (Sturm)

LUNCH

1.00 MESUR-Marsnet coordination (Bourke)

1.30 Possible SEI Pathfinder instruments (Kaplan)

1.45 Russian small stations (Blamont)

2.15 General discussion of Pathfinder (all)

3.00 MESUR SDT activities (Squyres)

3.30 Executive session

Future role of MarsSWG
Membership

5.00 Adjourn

c)

SIGN-IN SHEET

Mars Science Working Group

June 17, 1992
Capitol Holiday Inn
Washington, DC

Name	Affiliation
Louis Friedman	The Planetary Society
Tommy Dickerson	NASA HQ
Carl Pilcher	NASA HQ
John McNamee	JPL - MESUR
[illegible] Lehman	JPL - MESUR
A. Schock	Fairchild Space
Bruce McCandless	Martin Marietta
[illegible] Rosai	NASA HQ SL
Arthur L. Lane	JPL
Henry C. Brinton	NASA HQ
Mike Duke	NASA JSC
Douglas O'Handley	NASA HQ
[illegible] Bowie	JPL
Michael Meyer	LESC / NASA
Doug Blanchard	JSC/NASA
Don Pinkler	NASA HQ
John Rummel	NASA HQ
Joe Boyce	NASA HQ
David Paige	UCLA

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SIGN-IN SHEET

Mars Science Working Group

June 17, 1992
Capitol Holiday Inn
Washington, DC

Name	Affiliation
Larry H. Bruce	Univ. of Michigan
John Krehbiel	SLC
Matthew Golombek	JPL
[illegible]	UCLA
Paul M. Siemers	NASA/LaRC
Jacques BLAMONT	CNES
Wes Huntress	NASA
Harold P. Klein	Santa Clara U
[illegible] Nakamura	Univ [illegible]
[illegible] Allen	Caltech
TONY SPEAR	JPL
Corinne Buoni	SAIC
JOHN APPLEBY	SLC
DAVID KAPLAN	JSC/X
Ronald Greeley	ASU
Fred Duennebier	U. Hawaii
GARY OLHOEFT	USGS
WC Panter	NASA/HQ
RT GAMBER	MMC
[illegible]	NASA. ARC

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SIGN-IN SHEET

Mars Science Working Group

June 17, 1992
Capitol Holiday Inn
Washington, DC

Name	Affiliation
JOHN NIEHOFF	SAIC
MARIUS WEINREB	SAIC
Jim Martin	Consultant
Doug Nash	San Juan Inst.

Progress Report

Mars Aeronomy Study Team

R. Hartle, Chairman, GSFC
J. Luhmann, UCLA
L. Brace, U of Michigan
B. Jakosky, U of Colorado
(and several others)

Progress

- Formed science and engineering team to study possibility of using spacecraft and instruments from current GSFC missions to perform low cost Mars aeronomy mission. (first meeting 15-16 June)
- Concluded that best fit to Discovery was to use TIMED instruments on a SMEX spacecraft.
- Mission Name: Mars Upper Atmosphere Dynamics and Evolution mission

Action Plan

- Form a expanded science team to develop this mission concept.
- Conduct a mini-pre-Phase A Study of the mission.
- Present the concept to the Discovery Review Panel (Nov. 17-20, 1992)

Brace

Upper Atmosphere Dynamics and Evolution Discovery

Approach:

Small Explorer (SMEX) spacecraft carrying a subset of the TIMED instruments.

Relationship to other missions:

Fills in the spatial and scientific gaps between MO, Mars-94 and Planet B missions

Scientific Goals

Upper Atmosphere Dynamics (~60-200 km)

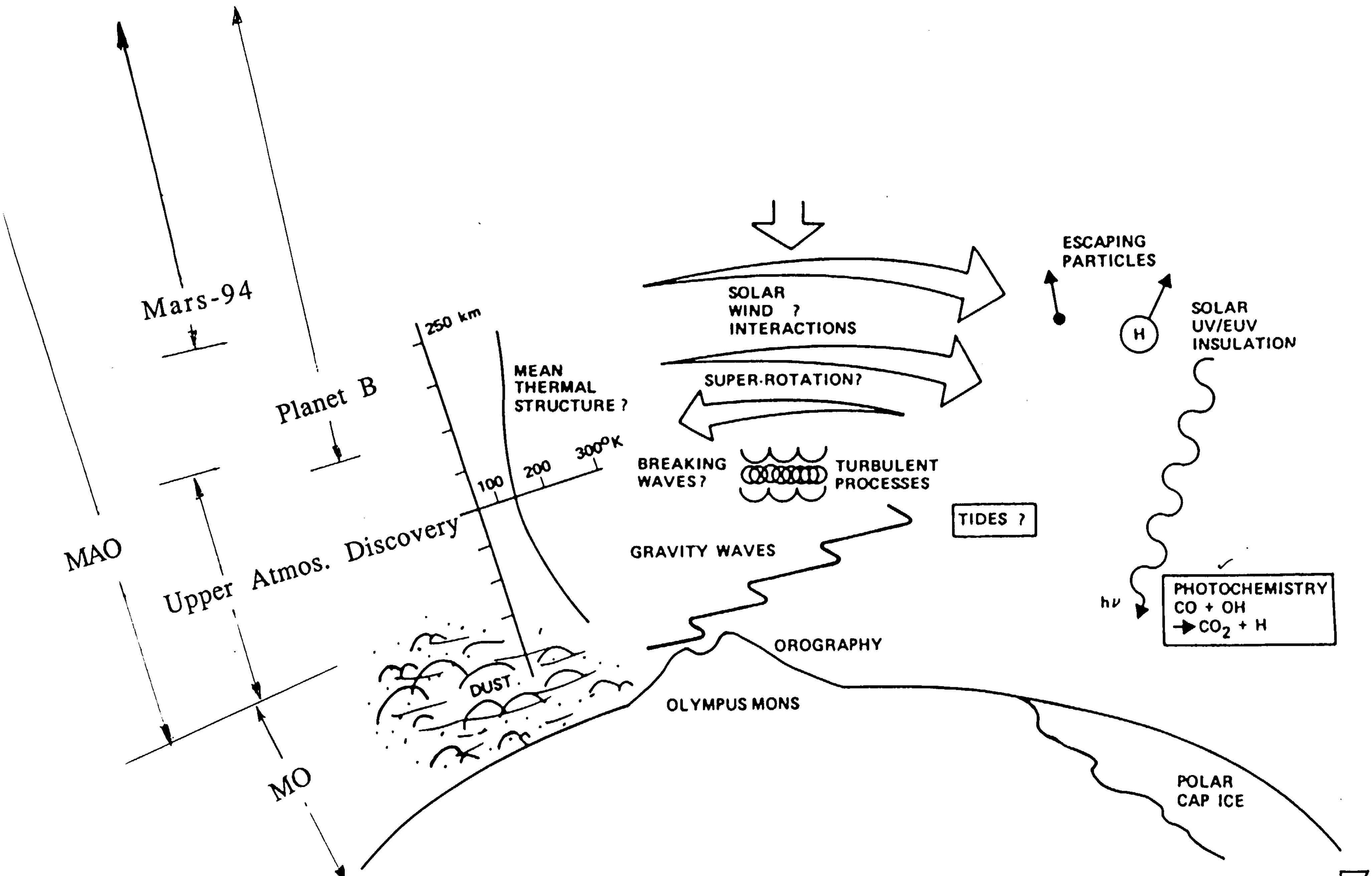
- Global structure and variability
- Winds, tides, gravity waves, global circulation

Atmosphere Evolution

- Thermal escape
- Non-thermal escape
- Isotope ratios

Ionosphere Physics

- Ion chemistry and energetics
- Effects of solar wind



Mars-94
Planet B
MAO
Upper Atmos. Discovery
MO
250 km
100
200
300°K
MEAN THERMAL STRUCTURE ?
SOLAR WIND ? INTERACTIONS
SUPER-ROTATION?
ESCAPING PARTICLES
H
SOLAR UV/EUV INSULATION
BREAKING WAVES?
TURBULENT PROCESSES
TIDES ?
GRAVITY WAVES
hν
PHOTOCHEMISTRY
CO + OH
→ CO2 + H
OROGRAPHY
DUST
OLYMPUS MONS
POLAR CAP ICE

Table V.2.1.a
Primary Strawman Instruments for TIMED-H and -L

Instruments	Acronym	Measured Parameters	Spacecraft H	Spacecraft L
A. Remote Sensing				
UV Spectrometer	UVS	O_3, NO_x, other minor constituents	X	X
Near Infrared Spectrometer/Photometer	NIRSP	$O_2(^1\Delta)$, (O_3), OH rot., H_2O	X	-
Fabry-Perot Interferometer	FPI	Wind, temperature and emission rate profiles	X	X
Imaging Photometer	IP	Wave structures	X	X
Global UV Airglow Imager	GUVI	Global Imaging of atmospheric UV emissions	X	-
Infrared Limb Sounder[1]	IRLS	Mesospheric CO_2,O_3,OH, NO.	-	X
Solar EUV Spectrometer[2]	SEUVS	Spectral Solar EUV and Xray fluxes	X	-
B. In-situ				
Neutral Mass Spectrometer/Wind and Temperature	NMSWT	Local gas composition, winds and temperature	X	X
Ion Mass Spectrometer	IMS	Ion composition	X	X
Langmuir Probe	LP	Electron/ion density, electron temperature	X	X
Energetic Particles Analyzer	EPA	Auroral electron and ion energy fluxes	X	-
Ion Drift Meter Retarding Potential Analyzer	IDM/RPA	Ion drift/Electric fields, ion temperature	X	X
Magnetometer	MAG	Currents	X	-
Accelerometer[3]	ACC	Total air density	X	X
Electric Field Detector/Plasma Wave Exp[4]	EFD/PWE	3 axis AC and DC electric fields	X	-

1 low duty cycle due to high power requirements
2 not needed on TIMED if done simultaneously on other mission(s)
3 non-PI class instrument.
4 contingent on feasiblity of booms at low periapsis altitude

MARS SCIENCE WORKING GROUP MEETING

PROJECT OVERVIEW

JUNE 17, 1992

A. SPEAR

MESUR SCIENCE WORKING GROUP MEETING

CONTENTS

m

MESUR SCIENCE WORKING GROUP MEETING
AGENDA

• PROJECT OVERVIEW	- SPEAR
• MISSION ANALYSIS	- McNAMEE
• PATHFINDER FLIGHT SYSTEM	- LEHMAN
• PATHFINDER MICROROVER AND INSTRUMENTS	- LANE

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6/17/92

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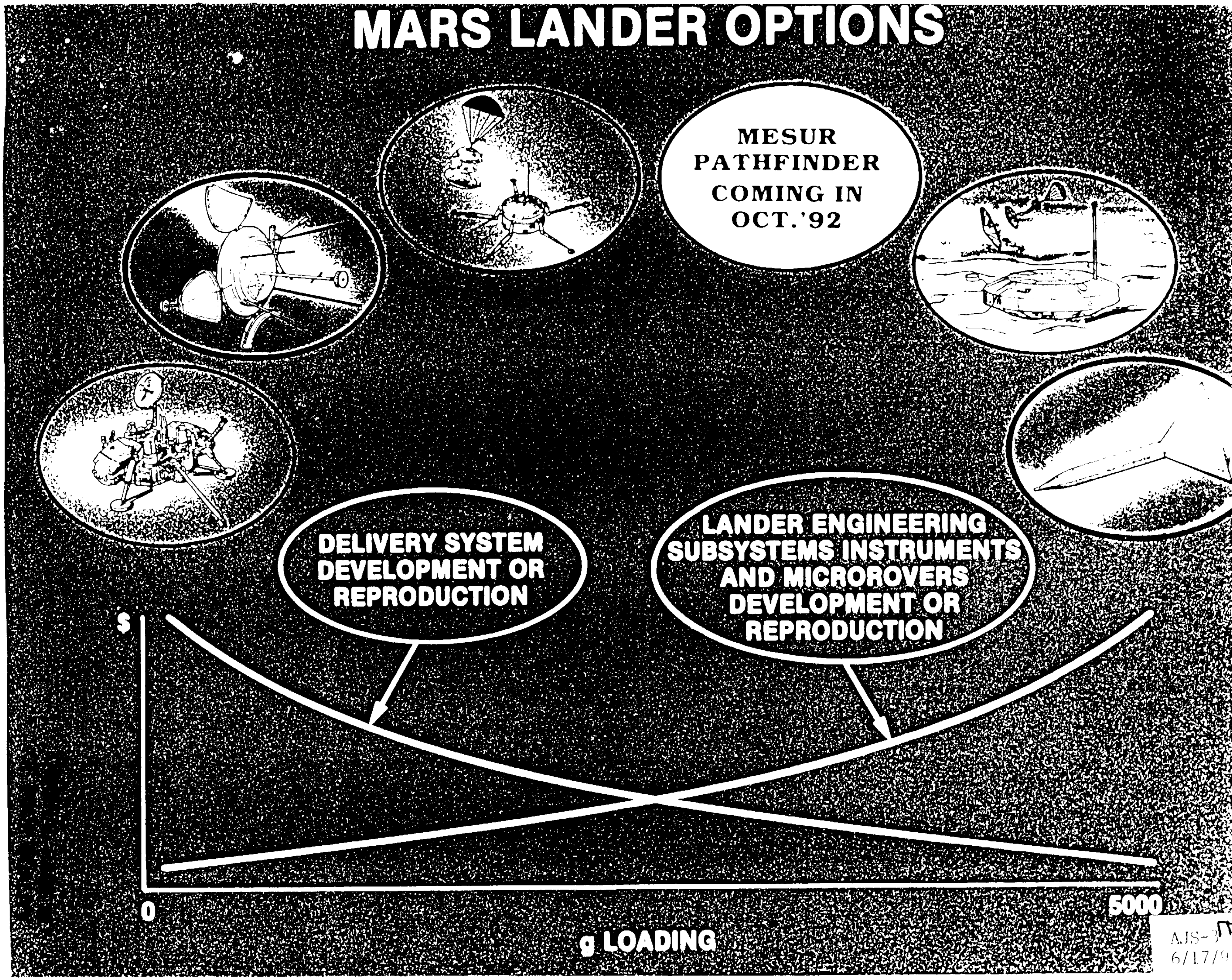
MARS LANDER OPTIONS
MESUR
PATHFINDER
COMING IN
OCT.'92
DELIVERY SYSTEM
DEVELOPMENT OR
REPRODUCTION
LANDER ENGINEERING
SUBSYSTEMS INSTRUMENTS
AND MICROROVERS
DEVELOPMENT OR
REPRODUCTION
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6/17/9

MESUR SCIENCE WORKING GROUP MEETING
STATUS AND PLANS

- AWARDED NETWORK IN NOVEMBER '91 AND PATHFINDER IN MARCH '92
- STUDYING AMES BASELINE CAREFULLY, BOTH TECHNICALLY AND PROGRAMMATICALLY
- WORKING CLOSELY WITH NASA AND MESUR SDT ON STUDY DIRECTION, CONSTRAINTS AND PRIORITIES
- UNDERSTAND CLEARLY
  - 150 MIL$ MAX FOR PATHFINDER
  - 150 MIL$ /YR MAX AND 1.0 BIL$ TOTAL FOR NETWORK
- **SUBJECT TO CONSTRAINTS, OUR JOB IS TO MAXIMIZE SCIENCE RETURN FOR NETWORK MISSION OVER '99, '01, '03 LAUNCH OPPORTUNITIES AND WITH THE FULL NETWORK IN OPERATIONS FOR ONE MARTIAN YEAR**

SDT = Science Definition Team

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6/17/92

m

MESUR SCIENCE WORKING GROUP MEETING
STATUS AND PLANS (Cont'd)

- STUDY DIRECTION
  - INCORPORATING FIXES
  - STUDYING SOLAR PANELS AS WELL AS RTGs
  - STUDYING DIRECT LINK VS COMM ORBITER
  - DEVELOPING AN UPRIGHT LANDING
  - STUDYING INSTRUMENTS DEPLOYMENT
  - STUDYING "MUST FLY" AND "PLUG-IN" INSTRUMENT CONCEPT
  - STUDYING USE OF MICROROVERS
  - STUDYING PATHFINDER AND NETWORK
  - STUDYING MISSION, FLIGHT SYSTEMS, GROUND DATA SYSTEM, MISSION OPERATIONS CONCURRENTLY
  - IN A SEARCH MODE FOR GOOD IDEAS AND AVAILABLE TECHNOLOGY

- POINTING TO AN OCTOBER '92 REVIEW OF PATHFINDER AND A DECEMBER '92 REVIEW OF NETWORK MISSION CONCEPTS, IMPLEMENTATION PLANS AND COST ESTIMATES

MESUR SCIENCE WORKING GROUP MEETING
STATUS AND PLANS (Cont'd)

- CONDUCTED CRUISE CARRIER AND COMM ORBITER VS DIRECT LINK WORKSHOPS WITH MARSNET
  - WILL FLY MARSNET TO MARS VIA COMMON OR SINGLE CRUISE CARRIERS
  - DEVELOPED DRAFT MARSNET CARRIER, COMM ORBITER AND DIRECT LINK INTERFACES
  - 2ND INTERFACE MEETING IN CANNES, WEEK OF JULY 27
  - MARSNET SUPPORT MUST NOT IMPACT PATHFINDER
- CONDUCTED LESSONS LEARNED SYMPOSIUM WITH VIKING, PIONEER VENUS, GLL PROBE, CSAD, RUSSIAN LUNA, VERNERA, AND MARS LANDER PRESENTATIONS
- SET UP A PEER REVIEW OF PATHFINDER ENTRY, DESCENT, LANDING APPROACHES FOR AUGUST 5TH
- VISITING RUSSIANS TO EXPLORE PATHFINDER BUYS
- DEVELOPING A PATHFINDER INSTRUMENT SELECTION STRATEGY INVOLVING PI SUPPORT
- DEVELOPING A WHITE PAPER ON PATHFINDER IMPORTANCE
- DEVELOPING COST EFFECTIVE GDS AND MOS CONCEPTS

CSAD = Capsule System Advanced Development accomplished at JPL in late 60's as a part of its Advanced Development Program

GDS = Ground Data System

MOS = Mission Operations Systems

m

MESUR SCIENCE WORKING GROUP MEETING
NETWORK MISSION STATUS

STUDYING

- '99, '01, '03 BASELINE
  - EACH LANDER CARRYS LARGELY THE SAME INSTRUMENT SET, UTILIZES A TETHERED MICROROVER FOR INSTRUMENT DEPLOYMENT, LIMITED PLUG IN ONLY

- DEPLOYMENT OF NETWORK INSTRUMENTS OVER TWO LAUNCH OPPORTUNITIES FOLLOWED BY A THIRD LAUNCH FOCUSING ON SURFACE CHEMISTRY. ATMOS STRUCTURE AND IMAGING ON BOTH

- COMM ORBITER RELAY WITH DIRECT LINK

- DIRECT LINK ONLY

- FLYING MARSNET TO MARS, INTEGRATING MARSNET INTO LAUNCH AND FLIGHT OPERATIONS, PROVIDING MARSNET COMMUNICATIONS

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6/17/92

m

MESUR SCIENCE WORKING GROUP MEETING
ENTRY, DESCENT, LANDING PEER REVIEW GROUP

S. BAILEY	-	JSC ARTEMIS
M. EIDEN	-	MARSNET, ESTEC
M. FAGET	-	NASA RETIREE
A. FRIEDLANDER	-	SAIC
J. GERPHEIDE	-	JPL RETIREE, CHAIRMAN
J. GOODLETTE	-	MMC VIKING, RETIRE
W. HERMINA	-	SANDIA
C.C. JOHNSON	-	NASA RETIREE
T. KOPF	-	JPL
B. LAYMAN	-	JPL
C. PETERSON	-	SANDIA
G. SCOON	-	MARSNET, ESTEC
P. SIEMER	-	LANGLEY
M. TAUBER	-	AMES
V. KERZHANOVICH	-	RUSSIAN SPACE

TTI

DRAFT

MESUR SCIENCE WORKING GROUP MEETING
ENTRY/DESCENT/LANDING
SELECTION CRITERIA

1. AFFORDABLE FOR BOTH PATHFINDER AND NETWORK

2. SIMPLE AND RELIABLE

3. REQUIRES NO MAJOR DEVELOPMENTS

4. ABLE TO DELIVER A PAYLOAD ON THE MARS SURFACE UP TO 100KG FOR NETWORK AND 200KG FOR PATHFINDER WITH LESS THAN _____G'S ENTRY AND LANDING SHOCKS

5. ABLE TO LAND SAFELY AND UPRIGHT FOR THE VARIETY OF MARS SURFACE CONDITIONS EXPECTED TO BE ENCOUNTERED BY THE NETWORK

   - CAN IMPACT A ROCK WITH SIZE __________

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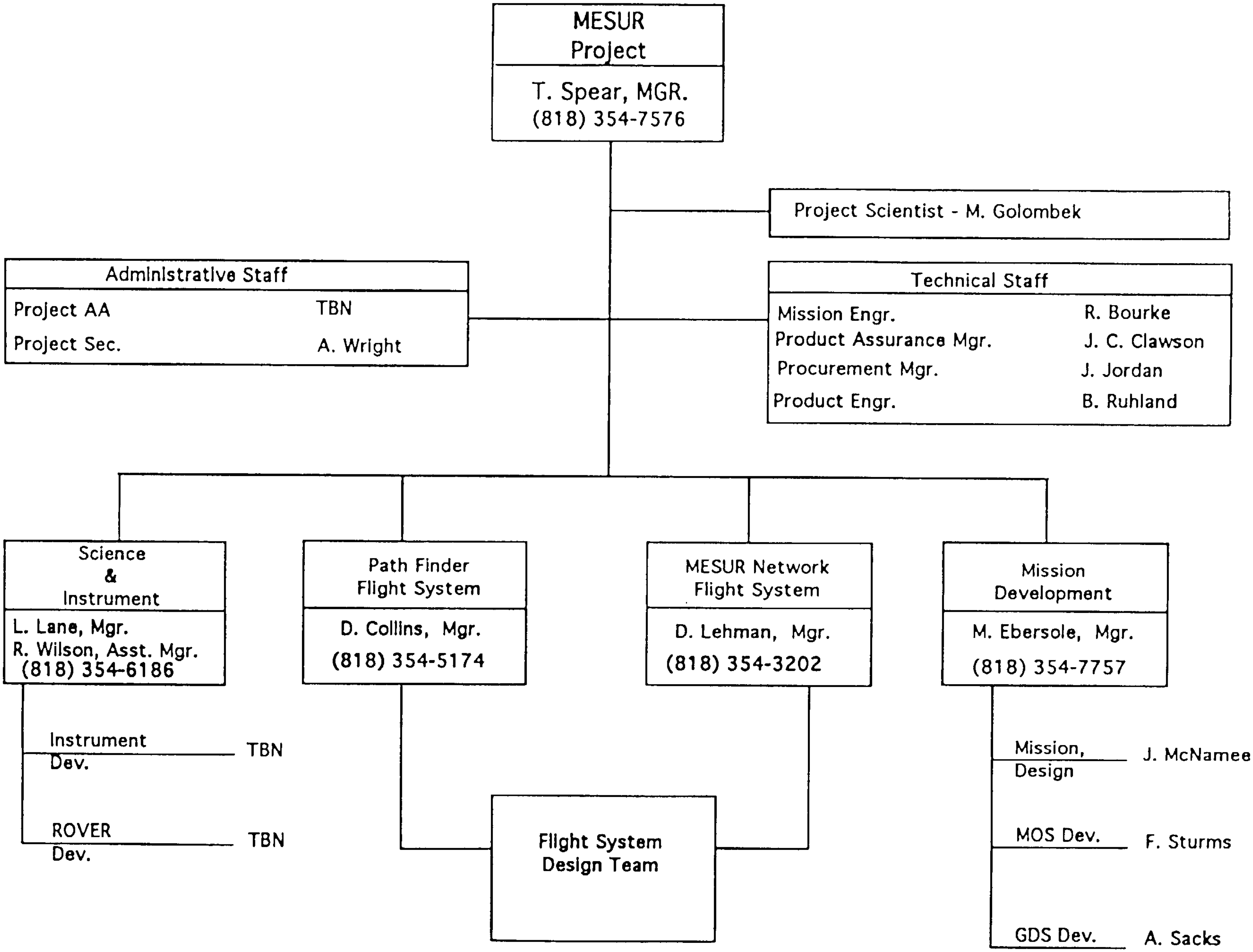
6/17/92

m

MESUR PROJECT ORGANIZATION



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MESUR SCIENCE WORKING GROUP MEETING
PATHFINDER AND NETWORK SEARCH MODE

- LOOKING WITHIN JPL, OTHER NASA CENTERS, INDUSTRY, EUROPE AND RUSSIA FOR GOOD IDEAS AND AVAILABLE TECHNOLOGIES:
    - HOLDING "ONE ON ONE" MEETINGS WITH INDUSTRY ON PATHFINDER AND NETWORK FLIGHT SYSTEM SUPPORT, COMM ORBITERS, DIRECT LINKS, ETC
    - CONSULTING WITH FAGET AND JOHNSON OF SPACE INDUSTRIES
    - MEETING WITH FORD AND VOLVO OTHERS ON AIRBAGS AND CRUSHABLE MATERIAL RESEARCH
    - INTERACTING WITH AMES, JSC, LANGLEY, SANDIA
    - SEARCHING FOR AVAILABLE TECHNOLOGY WITH IN INDUSTRY, NASA AND DOD

m

MESUR SCIENCE WORKING GROUP MEETING
WANTED

- AVAILABLE REGGEDIZED, SPACE PROVEN SUBSYSTEMS FOR PATHFINDER
- LIGHTER, SMALLER, RUGGEDIZED, LONGER LIVED, SUBSYSTEMS FOR NETWORK WITH DEVELOPMENT OR SPACE FLIGHTS COMPLETE BY '96
- AEROSHELLS, AIRBAGS, CRUSHABLE MATERIAL, PARACHUTES, PARACHUTES WITH ROCKETS
- SOLAR PANELS WHICH CAN WORK IN MARTIAN SURFACE FOR MANY YEARS
- SMALL, RUGGEDIZED, SPACE PROVEN BATTERIES THAT CAN WORK ON MARTIAN SURFACE, IN PARTICULAR ITS COLD ENVIRONMENT
- SMALL, RUGGEDIZED, SPACE PROVEN COMPUTERS AND SOLID STATE MEMORY
- SMALL, RUGGEDIZED, SPACE PROVEN MOTORS, SEALS, LUBRICANTS, DEVICES THAT CAN WORK FOR AT LEAST ONE YEAR ON MARTIAN SURFACE, IN PARTICULAR ITS COLD AND DUSTY ENVIRONMENT
- SMALL, RUGGEDIZED, SPACE PROVEN, EFFICIENT, SOLID STATE UHF TO X-BAND TRANSMITTERS AND RECEIVERS
- COMMANDABLE, LOW POWER DATA COMPRESSION CHIPS
- SMALL, RUGGEDIZED, SPACE PROVEN, STEERABLE LANDER ANTENNAS, VHF TO X-BAND, MEDIUM TO HIGH GAIN
- SMALL, RUGGEDIZED, SPACE PROVEN SENSORS

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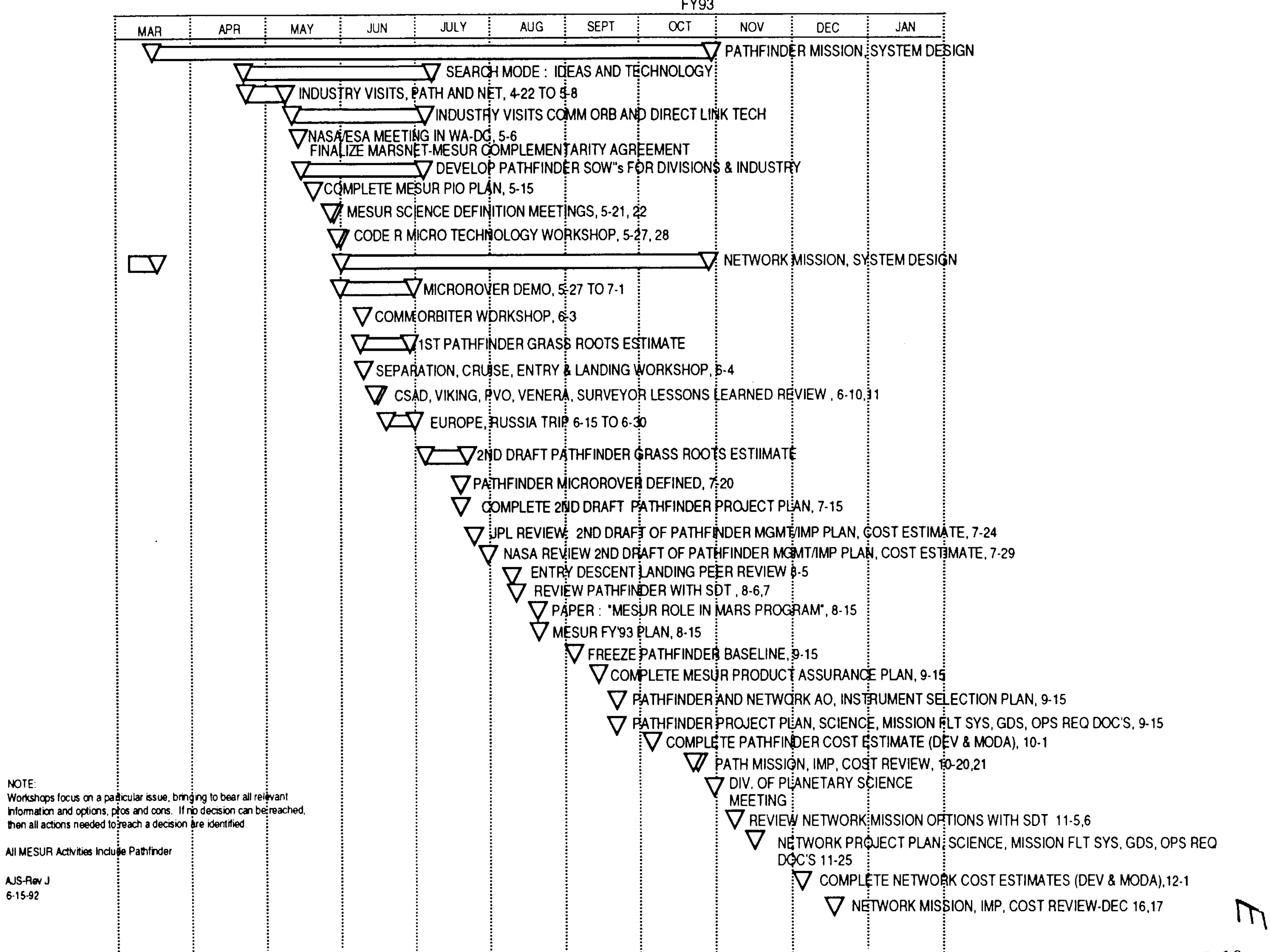
6/17/92

M

MESUR FY '92/'93 SCHEDULE



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MESUR PATHFINDER AND NETWORK SCHEDULE

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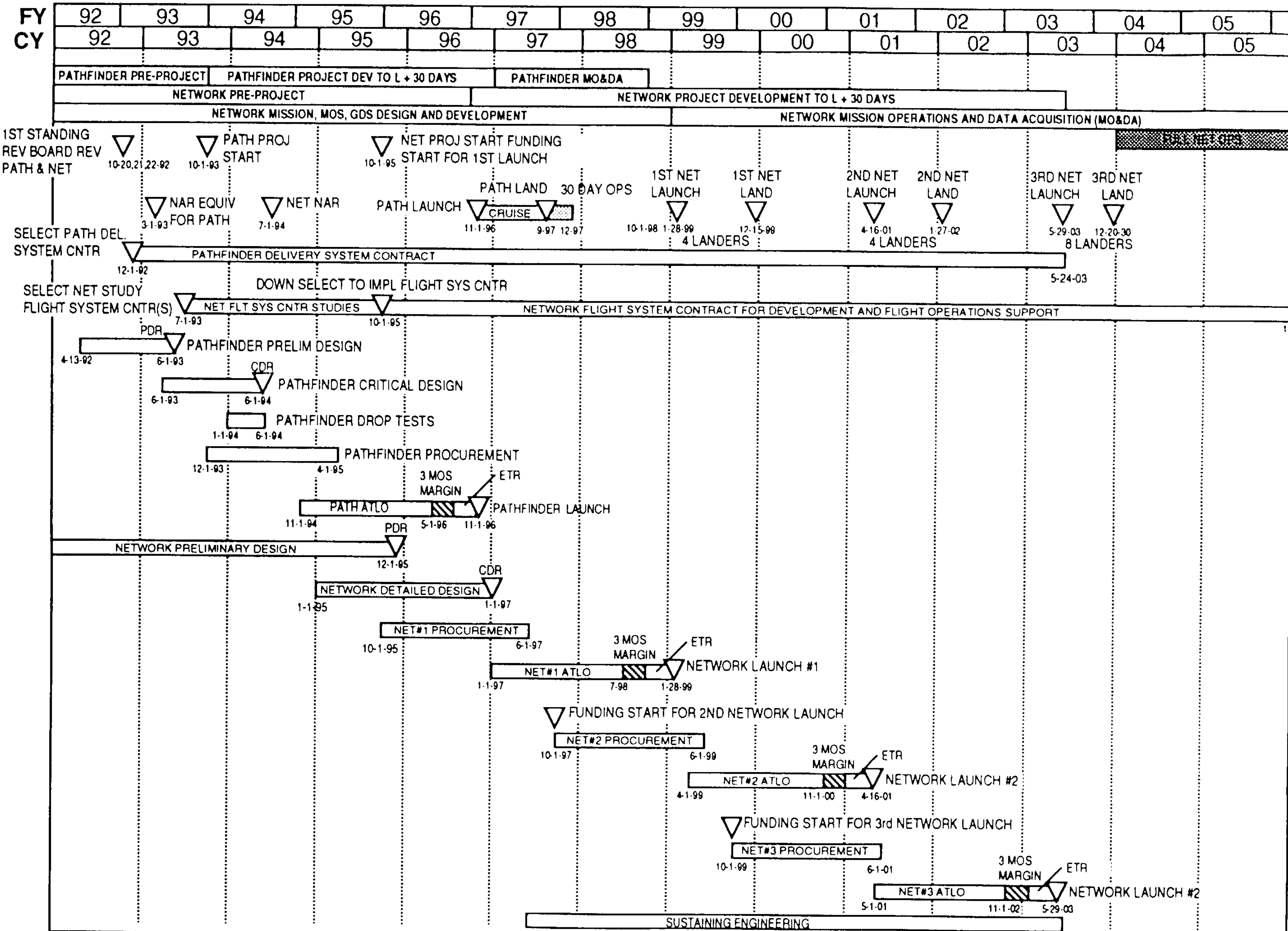
5/18/92



ATLO - ASSEMBLY, TEST AND LAUNCH OPS
CDR - CRITICAL DESIGN REVIEW
GDS - GROUND DATA SYSTEM
MO&DA - MISSION OPERATIONAL AND DATA ACQUISITION
MOS - MISSION OPERATIONS
NAR - NON-ADVOCACY REVIEW
PDR - PRELIMINARY DESIGN REVIEW

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FIGURE 2. MESUR PATHFINDER AND NETWORK SCOPE

PATHFINDER VALUE FOR NETWORK

		DELIVERY SYSTEM	LANDER SYSTEM	INSTRUMENTS AND MICROROVER	PROJECT MGMT, MISSION AND SYSTEM DESIGN, MOS AND GDS DEV
PATHFINDER	ONE FLIGHT SYSTEM AT '96 LAUNCH	NOTE: THIS DEVELOPMENT HAS A MAJOR IMPACT ON ALL OTHER FLIGHT SYSTEM DEVELOPMENTS AND ALL REPRODUCTIONS DEVELOPMENT FOR NETWORK PROTOFLIGHT UNIT	PARTIAL DEVELOPMENT FOR NETWORK PROTOFLIGHT UNIT	PARTIAL DEVELOPMENT FOR NETWORK SELECTED PROTOFLIGHT UNITS	ONE PROJECT TEAM FOR PATHFINDER AND NETWORK PARTIAL MOS AND GDS
		7 MILS AND 19 MOS PRE-PROJECT 150 MIL$ AND 37 MOS PROJECT START (FY94) TO LAUNCH			
NETWORK	FOUR FLIGHT SYSTEMS ON '99 LAUNCH	PATHFINDER UPGRADE PROTOFLIGHT UNIT FOUR FLIGHT UNIT PRODUCTION	PATHFINDER UPGRADE COMPLETE DEVELOPMENT PROTOFLIGHT UNIT FOUR FLIGHT UNIT PRODUCTION	PATHFINDER UPGRADES COMPLETE MUST FLY DEV COMPLETE SOME PLUG IN DEV PROTOFLIGHT UNITS FOUR FLIGHT UNIT PRODUCTION	EXPAND MOS AND GDS SUSTAINING ENGINEERING
		16-24 MIL$ AND 45 MOS PRE-PROJECT 375 MIL$ AND 40 MOS PROJECT START (FY96) TO LAUNCH			
	FOUR FLIGHT SYSTEMS ON '01 LAUNCH	SIX TO EIGHT FLIGHT UNIT PRODUCTION SUSTAINING ENGINEERING	SIX TO EIGHT FLIGHT UNIT PRODUCTION SUSTAINING ENGINEERING	SIX TO EIGHT FLIGHT UNIT PRODUCTION ADDITIONAL PLUG IN DEV SUSTAINING ENGINEERING	EXPAND MOS AND GDS SUSTAINING ENGINEERING
		325 MIL$ AND 42 MOS PROJECT START (FY98) TO LAUNCH			
	EIGHT FLIGHT SYSTEMS ON '03 LAUNCHES	FOUR TO SIX FLIGHT UNIT PRODUCTION SUSTAINING ENGINEERING	FOUR TO SIX FLIGHT UNIT PRODUCTION SUSTAINING ENGINEERING	FOUR TO SIX FLIGHT UNIT PRODUCTION ADDITIONAL PLUG IN DEV SUSTAINING ENGINEERING	COMPLETE MOS AND GDS SUSTAINING ENGINEERING
		300 MIL$ AND 42 MOS PROJECT START (FY00) TO LAUNCH			

NOTE: MAY NEED TO ACCOMADATE A COMM ORBITER DEVELOPMENT FOR NETWORK
DELIVERY SYSTEM = ELEMENTS OF CRUISE STAGE AND ENTRY, DESCENT, LANDING STAGES
FLIGHT SYSTEM INCLUDES ALL CRUISE, DELIVERY, LANDER STAGES
LANDER SYSTEM INCLUDES ELEMENTS OF CRUISE AND LANDING STAGES

GDS - GROUND DATA SYSTEM
MOS - MISSION OPERATIONS SYSTEM OR MONTHS

MESUR SCIENCE WORKING GROUP MEETING
PATHFINDER IMPORTANCE TO NETWORK

- PATHFINDER PROVIDES THE OPPORTUNITY TO ACCOMPLISH IMPORTANT DEVELOPMENTS FOR NETWORK

  - ALLEVIATES PRESSURE ON ACCOMPLISHING BOTH DEVELOPMENT AND PRODUCTION FOR '99 LAUNCH

- MOST IMPORTANT DEVELOPMENT IS DELIVERY SYSTEM[1]
  - INFLUENCES DEVELOPMENT AND BUILD OF ALL LANDERS
  - HARD LANDING REQUIRES MORE $ FOR LANDERS
  - SOFTER LANDING REQUIRES LESS $ FOR LANDERS

- PATHFINDER LANDER WILL BE A PARTIAL DEVELOPMENT FOR NETWORK
  - COMPLETION OF COMM, POWER, THERMAL, DATA SYSTEM, INSTRUMENTS, LIFETIME, PACKAGING DEVELOPMENTS WILL REMAIN AS NETWORK CHALLENGES

- PATHFINDER GOALS: DEPLOY A MICROROVER AND DO SIGNIFICANT SCIENCE

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[1] Elements of Cruise Stage and the Entry, Descent and Landing Stages resulting in an upright configuration on the surface

M

MESUR SCIENCE WORKING GROUP MEETING
PATHFINDER FLIGHT SYSTEM PRIORITY

- DEVELOP A COST EFFECTIVE DELIVERY SYSTEM FOR USE ON NETWORK, TO BE DEMONSTRATED ON PATHFINDER

- ACCOMPLISH A PARTIAL DEVELOPMENT OF THE NETWORK LANDER, TO BE DEMONSTRATED ON PATHFINDER. PRIORITIES:

    - LANDER PORTION OF DECELERATOR, I.E. CRUSHABLE MATERIAL, ETC
    - LANDER STRUCTURE WITH PHYSICAL SPACE AND SOME INTERFACES TO ACCOMMODATE NETWORK "MUST FLY" AND CANDIDATE "PLUG IN" INSTRUMENTS AND A MICROROVER
    - LANDER UPRIGHTING MECHANISM IF NECESSARY
    - INSTRUMENTATION AT LEAST SUFFICIENT FOR MISSION SUCCESS
    - DIRECT LINK TO EARTH AT LEAST SUFFICIENT FOR MISSION SUCCESS
    - POWER SUBSYSTEM AT LEAST SUFFICIENT FOR MISSION SUCCESS
    - THERMAL PROTECTION AT LEAST SUFFICIENT FOR MISSION SUCCESS
    - DATA SYSTEM AT LEAST SUFFICIENT FOR MISSION SUCCESS

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MESUR SCIENCE WORKING GROUP MEETING
PATHFINDER MISSION OBJECTIVES

- PRIMARY

  - VERIFICATION OF ENTRY AND DESCENT
  - VERIFICATION OF SAFE, UPRIGHT LANDING
  - VERIFICATION OF LANDER OPERATIONS FOR A PERIOD SUFFICIENT TO TRANSMIT A PANAROMIC IMAGE OF THE SURFACE

- SECONDARY

  - PANAROMIC IMAGE OF SURFACE
  - MICROROVER DEPLOYMENT AND SURFACE OPERATIONS
  - CODE X AND S SCIENCE EXPERIMENTS

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MESUR SCIENCE WORKING GROUP MEETING
PATHFINDER MISSION CONCEPT

- SINGLE AEROCRAFT, LAUNCH NOVEMBER '96, ARRIVAL JULY-SEPTEMBER '97
  - CRUISE, ENTRY/DESCENT, LANDER STAGES
  - LAUNCH VEHICLE: DELTA, TITAN II, OTHER
- LANDER SURFACE LIFE
  - FOR PRIMARY MISSION OBJECTIVES ONE WEEK
  - FOR MICROROVER OPERATIONS DEMO: 30 DAYS
  - FOR SEISMIC INSTRUMENT CALIBRATION: 1 YEAR
- FUNCTIONAL PROOF OF CONCEPT FOR MESUR
  - EMPHASIS ON ENGINEERING INSTRUMENTATION FOR DIAGNOSTIC PURPOSES
- CANDIDATE PAYLOAD INCLUDES BOTH CODE S AND X INSTRUMENTS:
  - MICROROVER
  - ATMOSPHERE STRUCTURE
  - SURFACE IMAGING
  - SEISMOMETER
  - WEATHER STATION
  - SOIL CHEMISTRY
- COMMUNICATIONS VIA DIRECT LINK (8 HOURS/DAY INTO 70M STATION)
  - WILL STUDY FEASIBILITY OF A RELAY LINK VIA MARS OBSERVER, MARS' 94, MARS '96 AS A BACKUP LINK
  - POWER TRADES: SOLAR PANEL/BATTERY VS BATTERY ONLY. NO RTG
  - MID-LATITUDE, LOW ELEVATION LANDING SITE

MESUR SCIENCE WORKING GROUP MEETING
PATHFINDER ASSUMPTIONS AND CONSTRAINTS

- MESUR PATHFINDER IS A DISCOVERY CLASS MISSION TARGETED FOR A FY'94 NEW START
    - WILL USE A QUICK REACTION PI PROCESS

- COST CAP FOR DEVELOPMENT THROUGH LAUNCH PLUS 30 DAYS OF $150M (FY'92$) FOR
    - FLIGHT SYSTEM
    - CODE S INSTRUMENTS
    - OPERATIONS AND GROUND DATA SYSTEM
    - RESERVE

- COST FOR MICROROVER, CODE X INSTRUMENTS AND THEIR SUPPORT, LAUNCH VEHICLE, TDA, OPERATIONS PAST 30 DAYS, AND APA/TAXES ARE IN ADDITION TO 150 M CAP

- NO FLIGHT SYSTEM HEAT STERILIZATION

- NASA COST REVIEW IN SPRING/SUMMER '93 REPLACES A NAR

TDA = Telecommunications and Data Acquisition

MESUR SCIENCE WORKING GROUP MEETING
PATHFINDER ASSUMPTIONS AND CONSTRAINTS (Cont'd)

- JPL IN-HOUSE MODE WITH CONTRACTED ENTRY/DESCENT STAGE AND OTHER SUBSYSTEMS
  - WILL USE LUNAR SCOUT PROJECT MANAGEMENT AND IMPLEMENTATION APPROACH, WILL USE JPL TEST BED
  - MAY USE MESUR FLIGHT SYSTEM CONTRACTOR(S) STARTING IN MID'93, INCENTIVIZED TO CONTRIBUTE/PARTICIPATE IN PATHFINDER
- HEAVY RELIANCE ON EXISTING HARDWARE AND/OR DESIGNS
  - EXAMPLE, MAY USE SCALED DOWN VIKING ENTRY DESIGN
  - PATHFINDER FUNCTIONS WILL BE LARGELY THE SAME FOR MESUR NETWORK
  - MESUR NETWORK H/W AND S/W MAY BE UPDATED: H/W MAY BE LIGHTER, SMALLER, MORE RELIABLE
  - PATHFINDER WILL USE SOLAR PANELS INSTEAD OF RTGs, POSSIBLY WITH RHU's
  - RISK MAY BE HIGHER THAN CURRENT PLANETARY PRODUCTS
    - EXAMPLE, LESS THAN CLASS A PARTS, LESS REDUNDANCY
    - RISK TO BE QUANTIFIED
    - ITEMS REQUIRED FOR PRIMARY MISSION OBJECTIVES WILL RECEIVE HIGHEST PRIORITY

NAR = Non Advisory Review
RHU = Radioisotopic Heater Units
RTG = Radioisotopic Thermal Generator

MESUR SCIENCE WORKING GROUP MEETING
MICROROVER ASSUMPTIONS AND CONSTRAINTS

- ROVER WILL CONDUCT CODE R TECHNOLOGY EXPERIMENTS
- ROVER CAN BE UP TO 10KG TOTAL MASS -- TARGET IS 7 KG
- ROVER OPERATIONS WILL OCCUR BETWEEN 10 AM - 3 PM EACH SOL
- ROVER WILL OPERATE ON MARTIANS SURFACE FOR MORE THAN 30 DAYS
- POWER, COMMAND, & COMMUNICATIONS VIA TETHER TO LANDER
    - 2-3 WATT AVERAGE LOAD
    - BATTERY ON ROVER TO HANDLE UP TO 30 WATT PEAK POWER
- ROVER CAPABILITY TO TRAVEL MORE THAN 50M FROM THE LEADER AND TO CIRCLE THE LANDER UP TO 270 DEGREE WITH TOTAL TETHER LENGTH OF 300M
- USE LANDER COMPUTER FOR MICROROVER CONTROL, DATA PROCESSING, DATA COMPRESSION AND STORAGE
    - BEHAVIORAL CONTROL ALGORITHMS AND SENSOR PROCESSING AT LEAST AS GOOD AS ROCKEY IV
    - IMAGE COMPRESSION
- USE "RHU's FOR THERMAL HEATING
    - USE 1/8 WATT STRIP HEATERS AT CRITICAL LOCATIONS

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MESUR SCIENCE WORKING GROUP MEETING
PATHFINDER APPROACH

- USE EXISTING DESIGNS AND EQUIPMENT
  - GO TO BEST SOURCES
- AVOID MAJOR DEVELOPMENTS, REINVENTING
- IMPLEMENT A SINGLE STRING SYSTEM
- ASSEMBLY QUICKLY AND TEST THOROUGHLY
  - START WITH EARLY TESTS IN TEST BED
- FOCUS ON PRIMARY OBJECTIVES FIRST
- ATTEMPT TO ACHIEVE SECONDARY OBJECTIVES ON A BEST EFFORT BASIS
- LEARN FROM AND EXPLOIT U.S. /RUSSIAN MARS '94 PROGRAM
- TRANSFER DEVELOPMENTS, LESSONS LEARNED TO NETWORK

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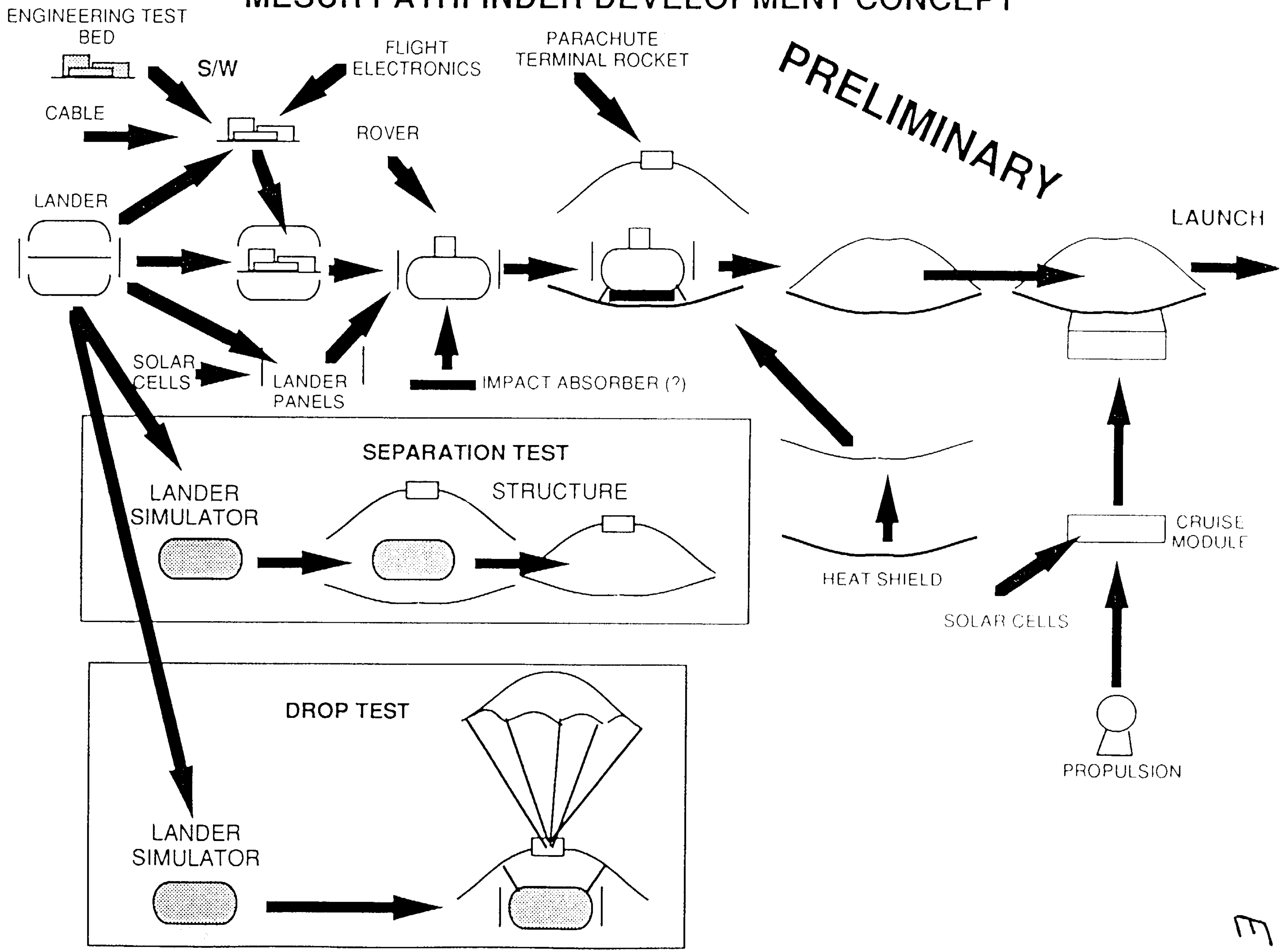
MESUR PATHFINDER DEVELOPMENT CONCEPT



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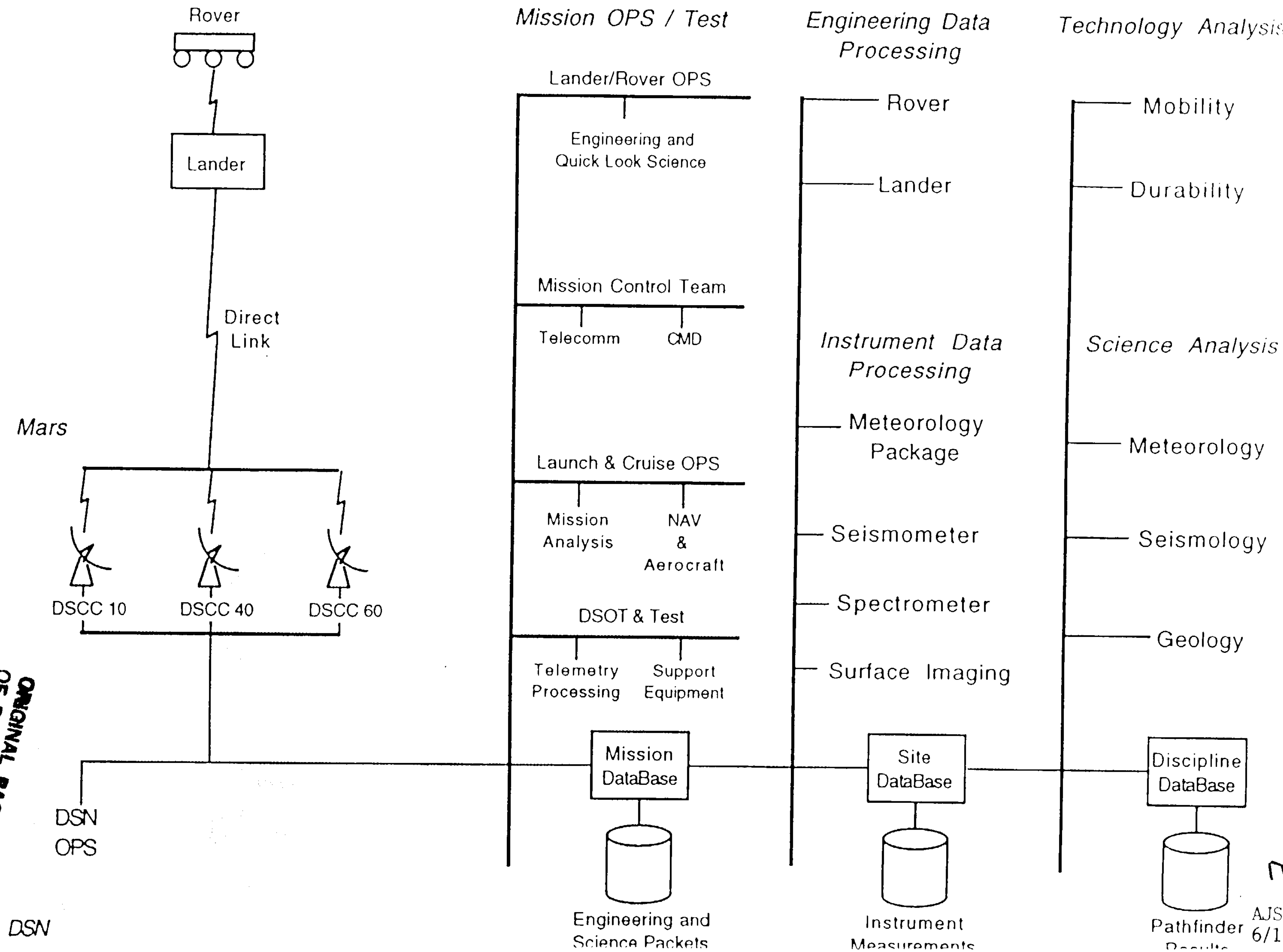
MESUR Pathfinder Data System



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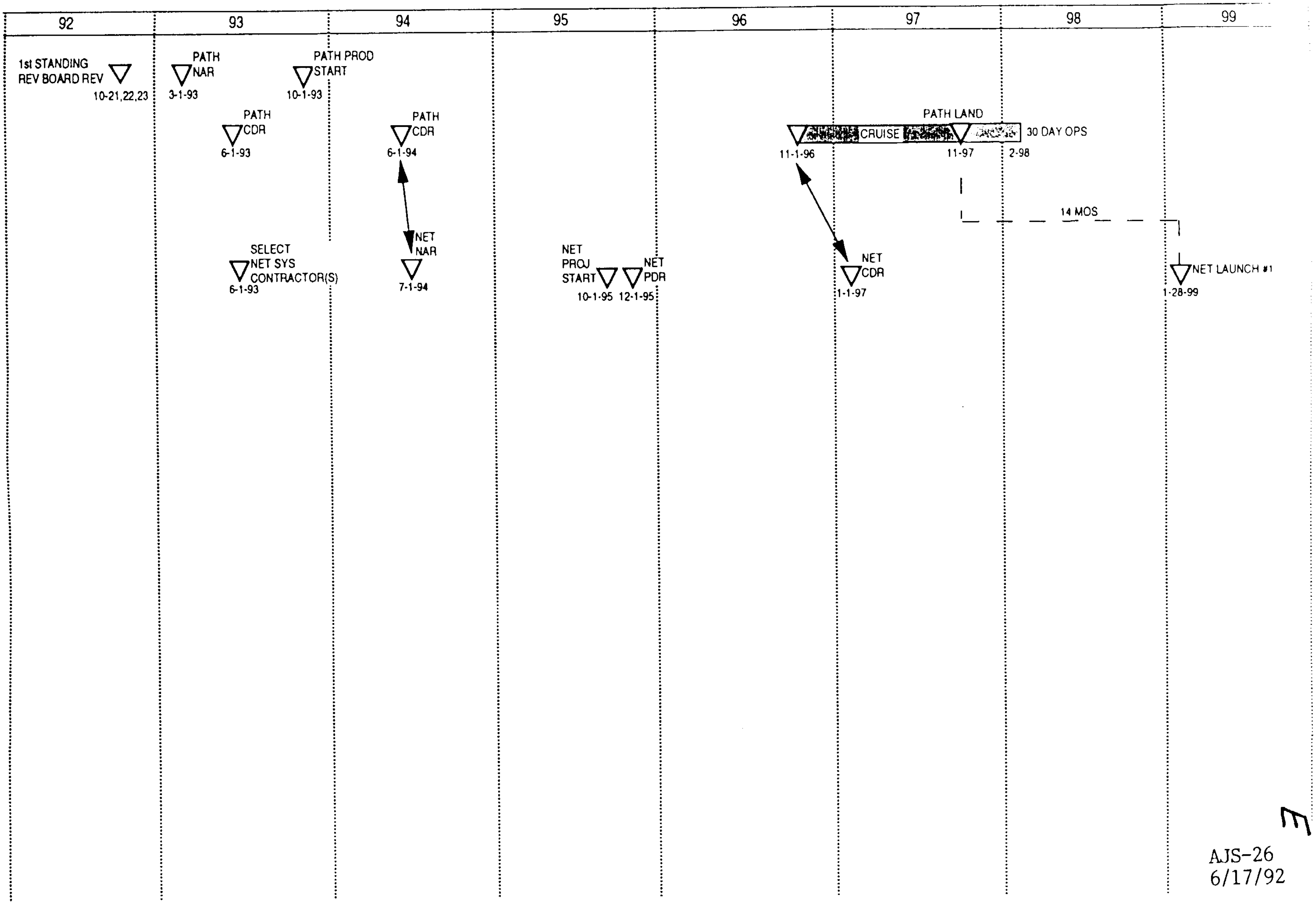
MESUR PATHFINDER AND NETWORK SCHEDULE COMPARISON
CY '92



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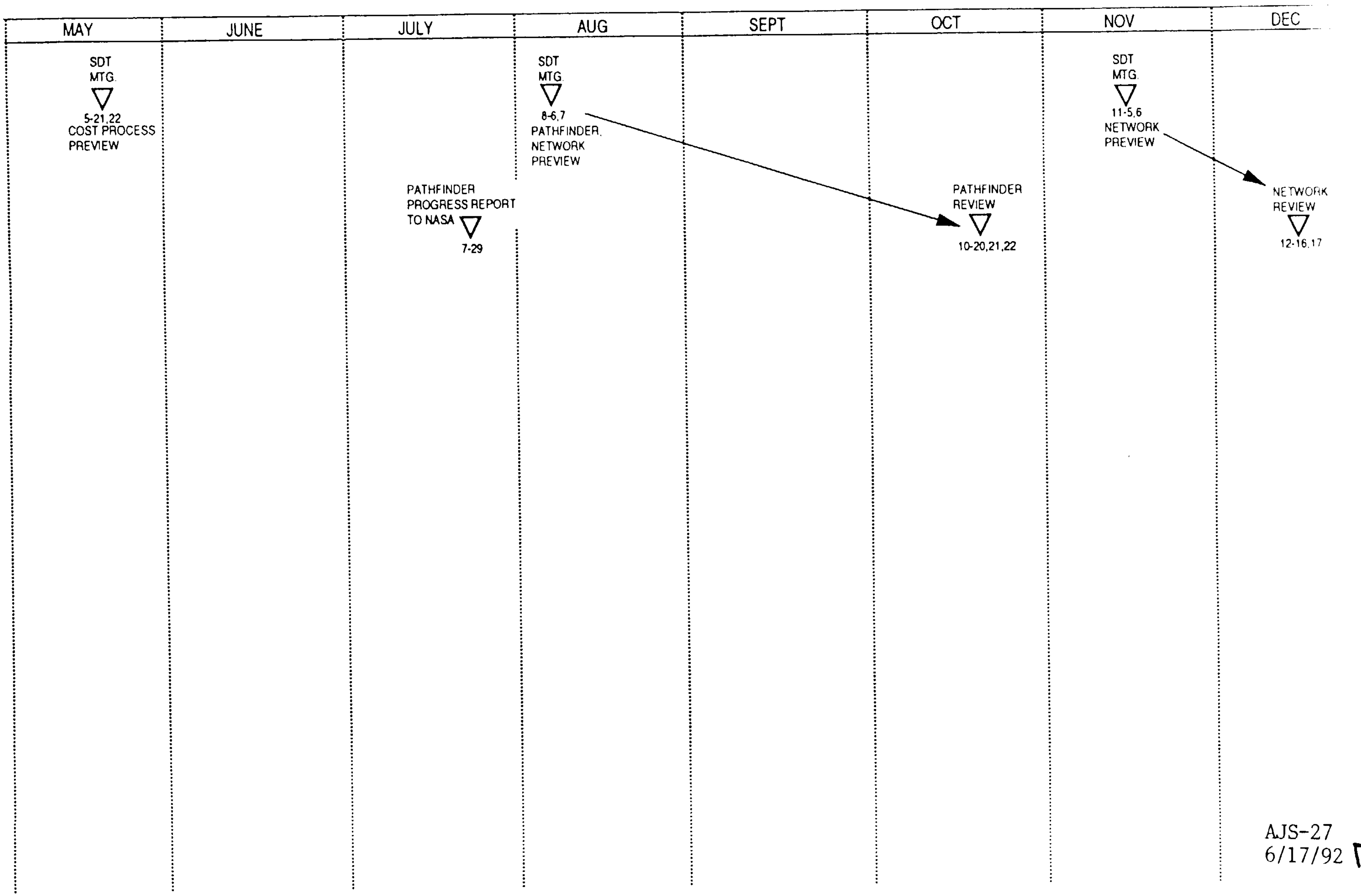
SCIENCE DEFINITION TEAM MEETINGS AND MESUR REVIEWS
CY '92



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MESUR PATHFINDER AND NETWORK

MISSION DESCRIPTIONS

Mars Science Working Group Meeting

June 17, 1992

John McNamee

Jet Propulsion Laboratory

Pasadena, CA

1996 MESUR PATHFINDER

Mission Description Topics

- Mission Overview
- Aeroentry Description
- Trajectory Characteristics
- Geometric Considerations
- Pathfinder Benefits

JPL

Pathfinder Mission Overview

- Launch via Delta II during 1996-7 Earth-Mars Opportunity
- Single free-flying aerocraft (includes propulsion system)
- 100 m/s allocated for Trajectory Correction Maneuvers and Site Targeting
- Entry configuration is spin stabilized, ballistic, Viking derived aeroshell (Uses SLA-561 ablative material for heat shield)
- Atmospheric structure data collected and relayed to Earth during entry
- Parachute deploy at ~10 km altitude, Mach 0.8
- Terminal deceleration system required to reduce surface contact speed
- Primary mission objectives are to enter atmosphere, descend, land, and achieve upright configuration. Secondary science and microrover operations goals.
- Limited arrival site targeting capability required - reduced nav complexity
- Direct communications link to Earth, solar array power source likely

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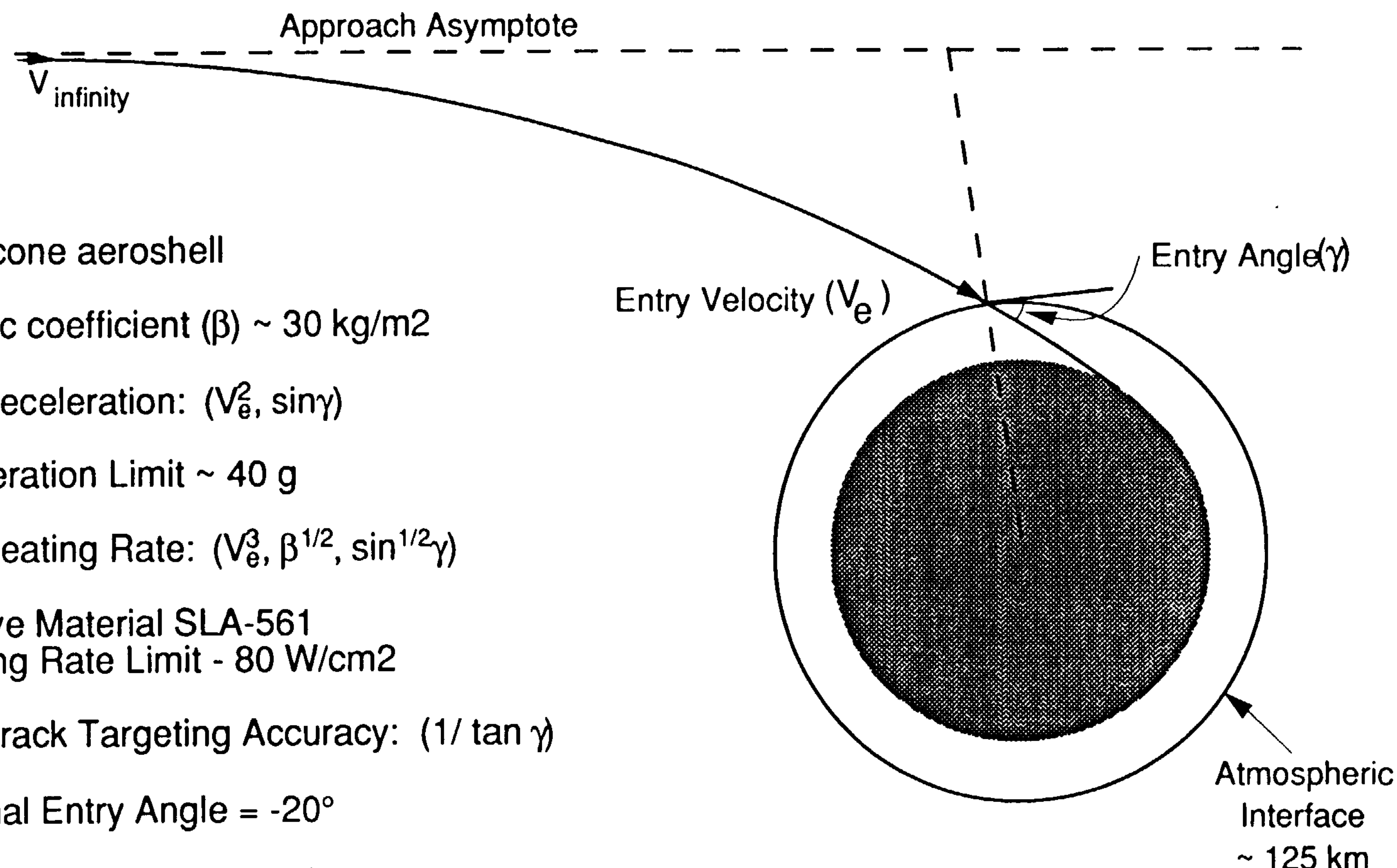
Aeroentry Overview



- Blunt-cone aeroshell
- Ballistic coefficient (β) ~ 30 kg/m2
- Max Deceleration: (V_e^2, sinγ)
- Deceleration Limit ~ 40 g
- Max Heating Rate: (V_e^3, $\beta^{1/2}$, $\sin^{1/2}\gamma$)
- Ablative Material SLA-561
  Heating Rate Limit - 80 W/cm2
- Downtrack Targeting Accuracy: (1/ tan γ)
- Nominal Entry Angle = -20°
- Entry Velocity Limit = 6.5 km/s
  (Assumes Catalytic Ablation)

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1996 MESUR PATHFINDER

Comparison of Entry Characteristics for Viking and Pathfinder

Parameter	Viking	Pathfinder
Approach	From Mars Orbit	Direct Hyperbolic
Attitude Control	Guided, RCS	Ballistic, Spinning
Ballistic Coefficient (kg/m^2)	65	30
Aeroshell Diameter (m)	3.5	2.5
Lift/Drag (L/D)	0.18	0
Entry Angle - 125 km (deg)	-13.7	-20
Entry Velocity - 125 km (km/s)	4.7	<7.0
Max Heat Rate (W/cm^2)	<29 (100*)	93 (Ames)
Integrated Heat Load (kJ/cm^2)	<1.53	1.9 (Ames)
Max Dynamic Pressure (kN/m^2)	<6.9	17.0 (Ames)
Max Deceleration (g's)	<11	30

* SLA-561 ablator material maximum operating limit per Ames

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Peak Heating Rate on Entry (W/cm^2) - Ballistic Coefficient 30 kg/m^2

V_e / γ	-15.0 deg	-17.5 deg	-20.0 deg
6.0 km/s	51	55	59
6.5 km/s	65	70	75
7.0 km/s	81	87	93*

Peak Heating Rate on Entry (W/cm^2) - Ballistic Coefficient 40 kg/m^2

V_e / γ	-15.0 deg	-17.5 deg	-20.0 deg
6.0 km/s	58	62	66
6.5 km/s	73	79	84
7.0 km/s	91	98	105

Maximum Deceleration on Entry (g's) - Ballistic Coefficient 30 kg/m^2

V_e / γ	-15.0 deg	-17.5 deg	-20.0 deg
6.0 km/s	17	19	22
6.5 km/s	19	23	26
7.0 km/s	23	26	30*

Maximum Deceleration on Entry (g's) - Ballistic Coefficient 40 kg/m^2

V_e / γ	-15.0 deg	-17.5 deg	-20.0 deg
6.0 km/s	16	19	21
6.5 km/s	19	22	25
7.0 km/s	22	26	29

* Ames baseline values

1996 MESUR PATHFINDER

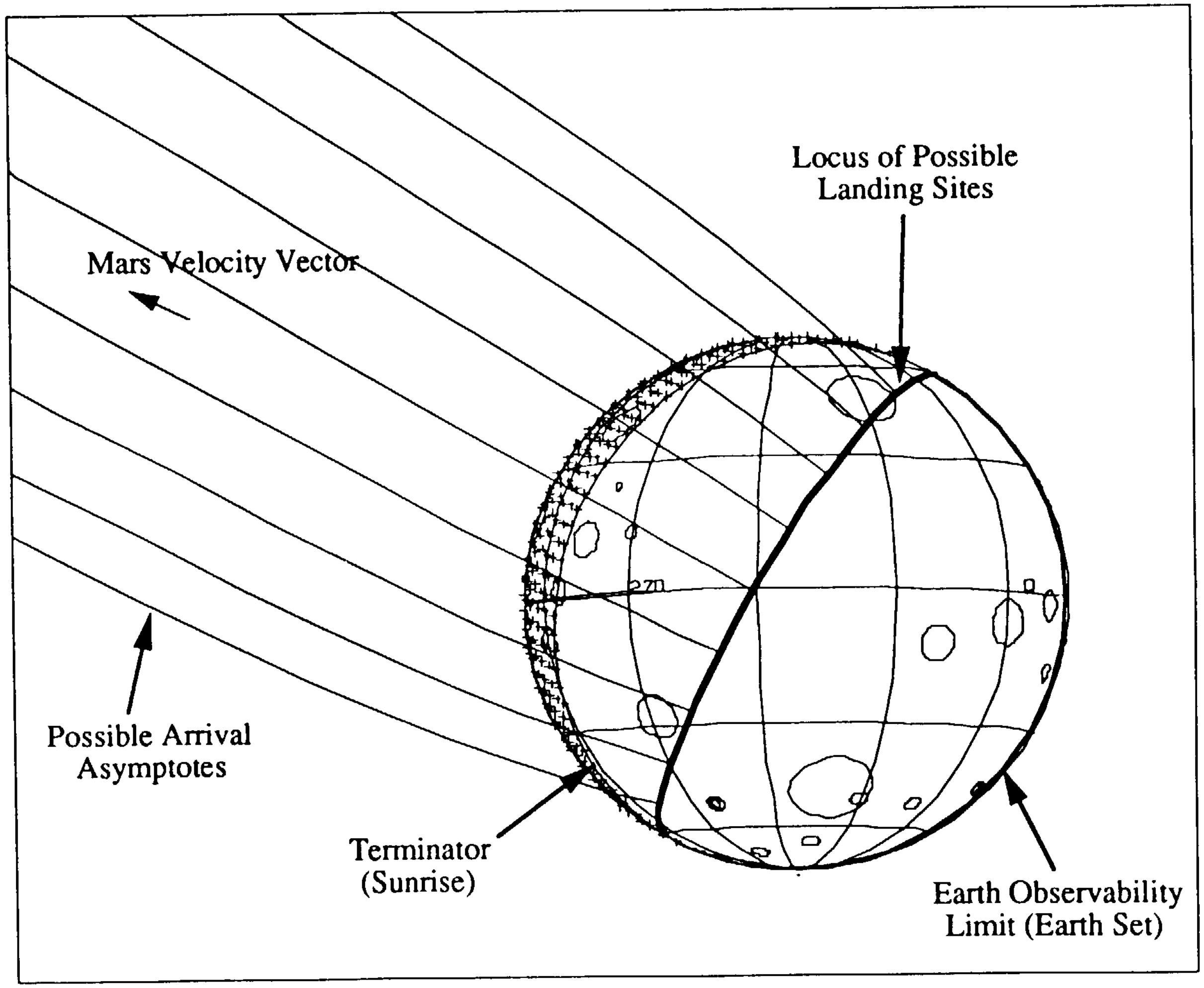
Reference Type II Trajectory Characteristics

Launch Date	Arrival Date	Launch Energy (km^2/s^2)	Launch Asymptote Declination	Approach Asymptote Declination	$V_{infinity}$ (km/s)	V_{entry} (km/s)
11/23/96	11/10/97	10.0	21.8°	-27.9°	3.9	6.3
12/02/96	11/10/97	9.2	28.1°	-30.5°	3.9	6.3
12/12/96	11/10/97	10.0	35.5°	-34.4°	3.9	6.3

<u>Arrival Conditions on 11/10/97:</u>

- Mars - Earth distance: 292 million km
- Mars - Sun distance: 210 million km
- Aerocentric longitude of the Sun (Vernal equinox reference): 212°
- Declination of the Sun: -14°

MESUR Pathfinder Reference Launch Period



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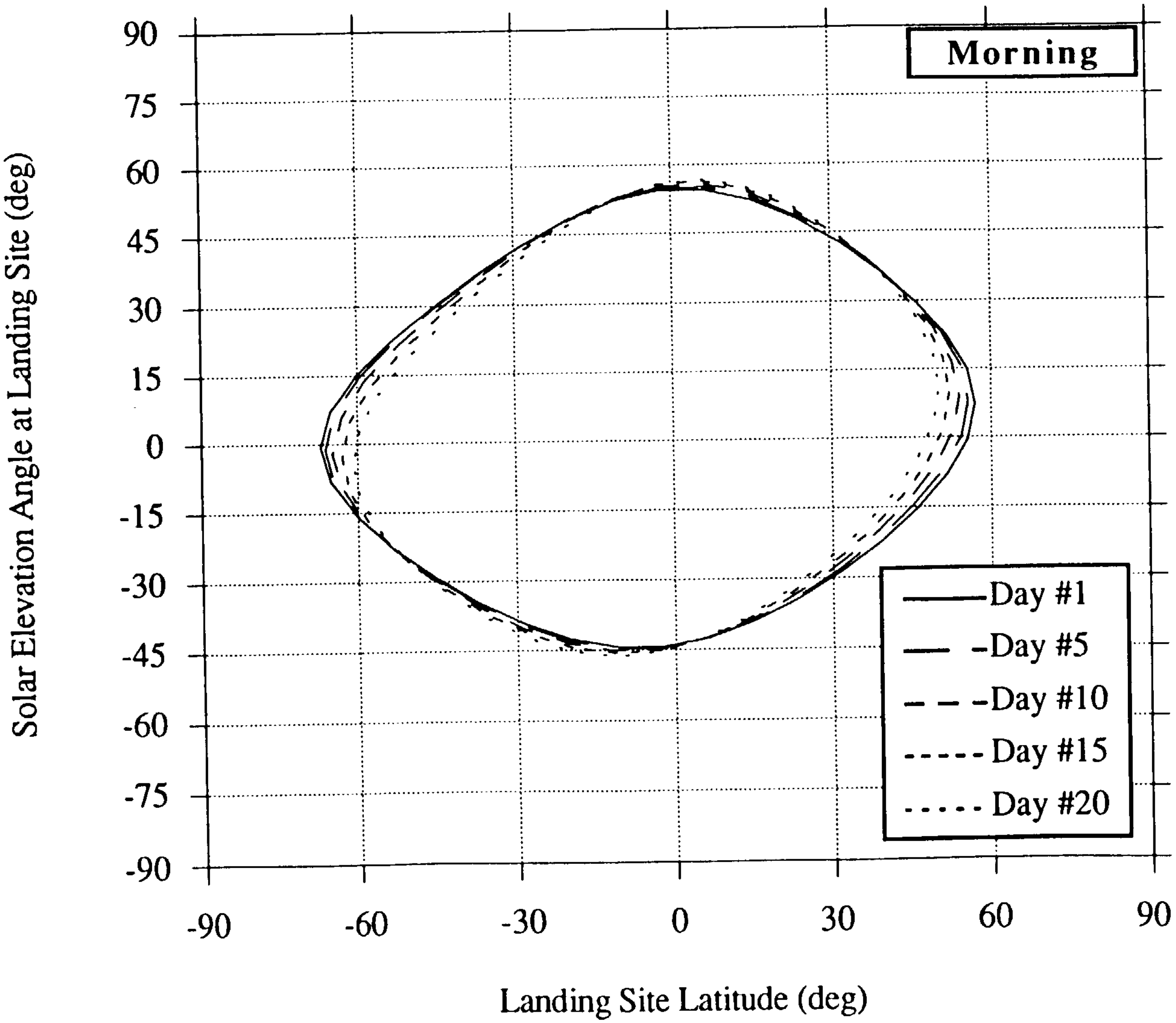
MESUR Pathfinder Reference Launch Period



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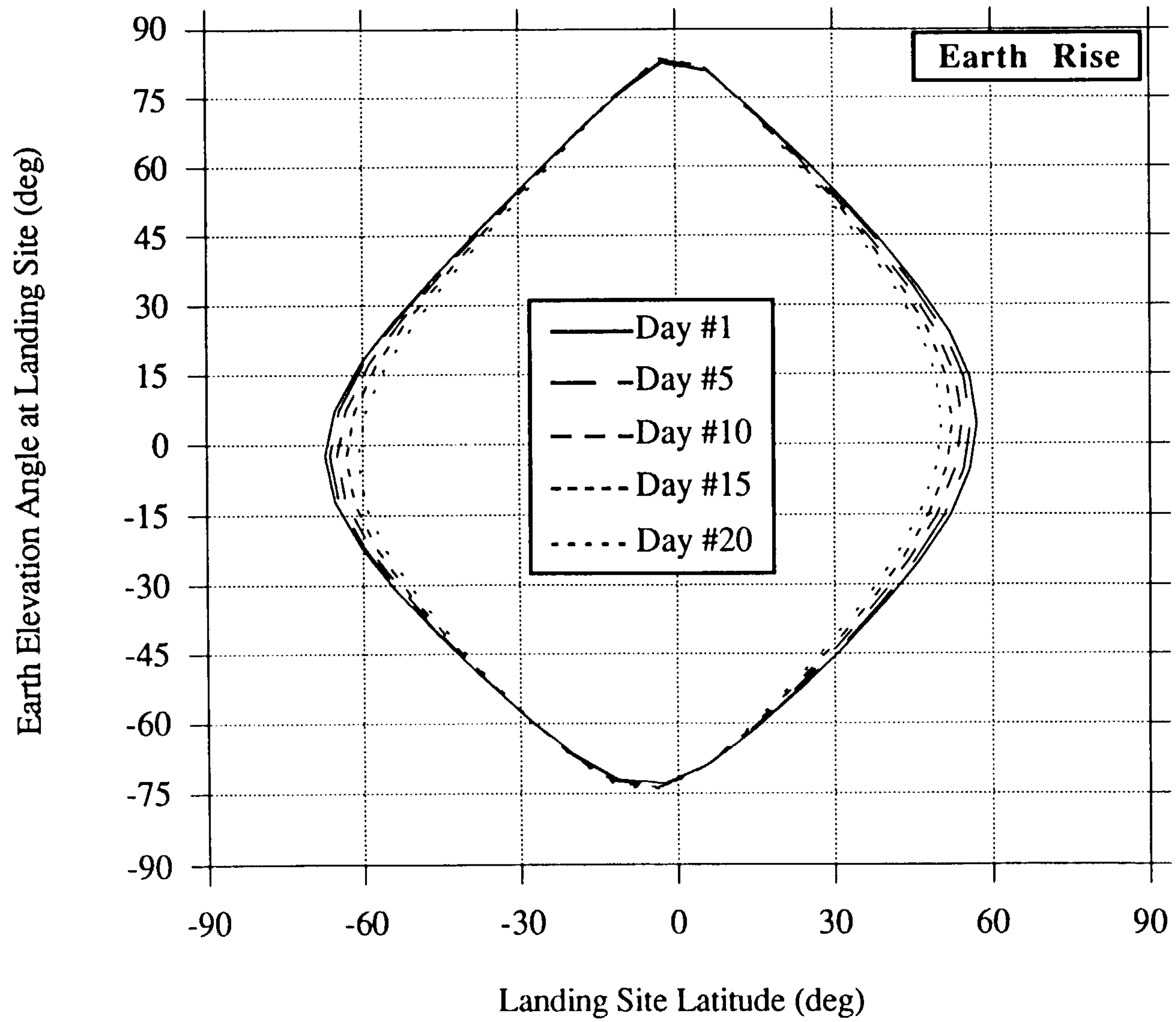
MESUR Pathfinder Reference Launch Period



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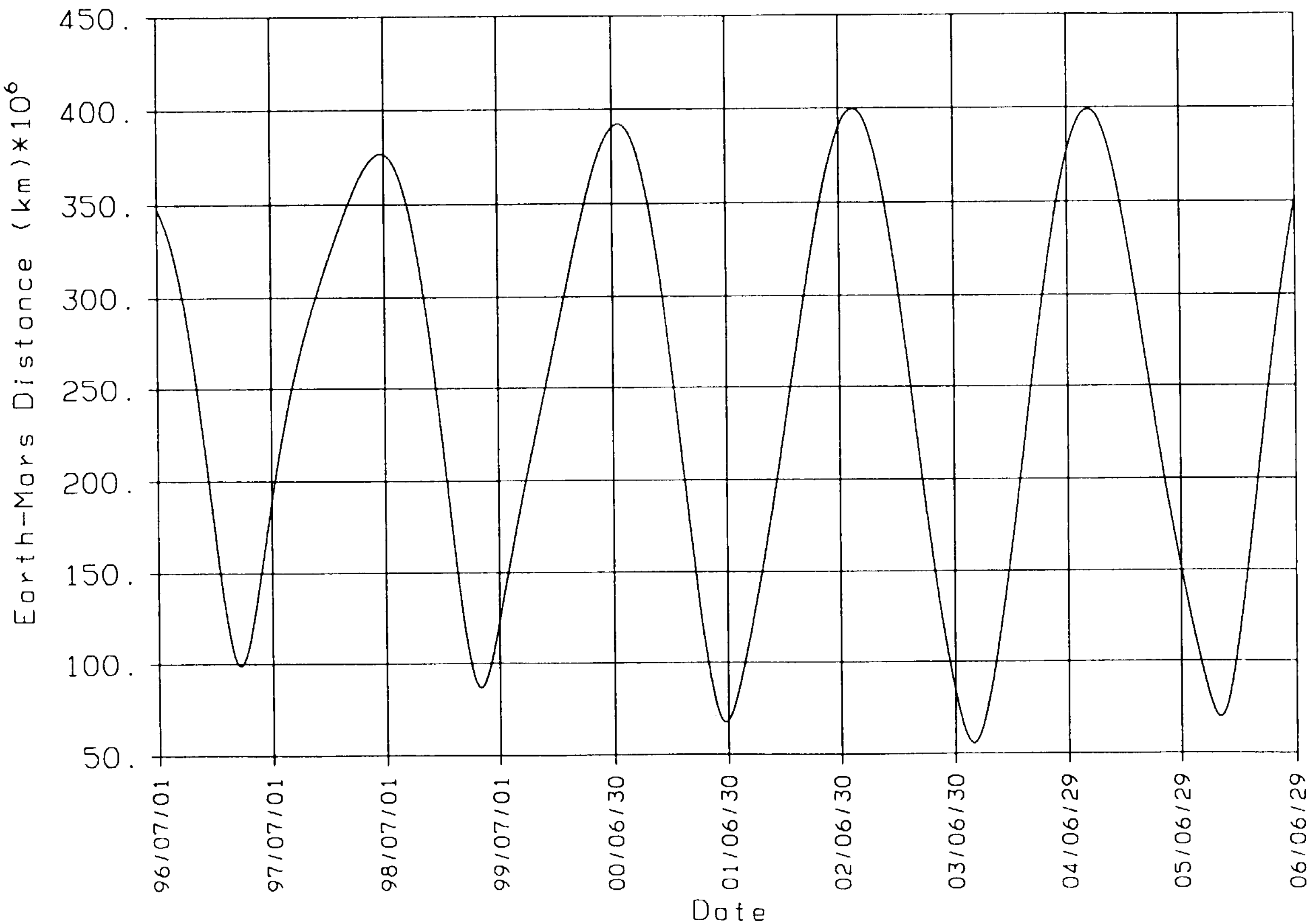
Earth-Mars Range (1996-2006)



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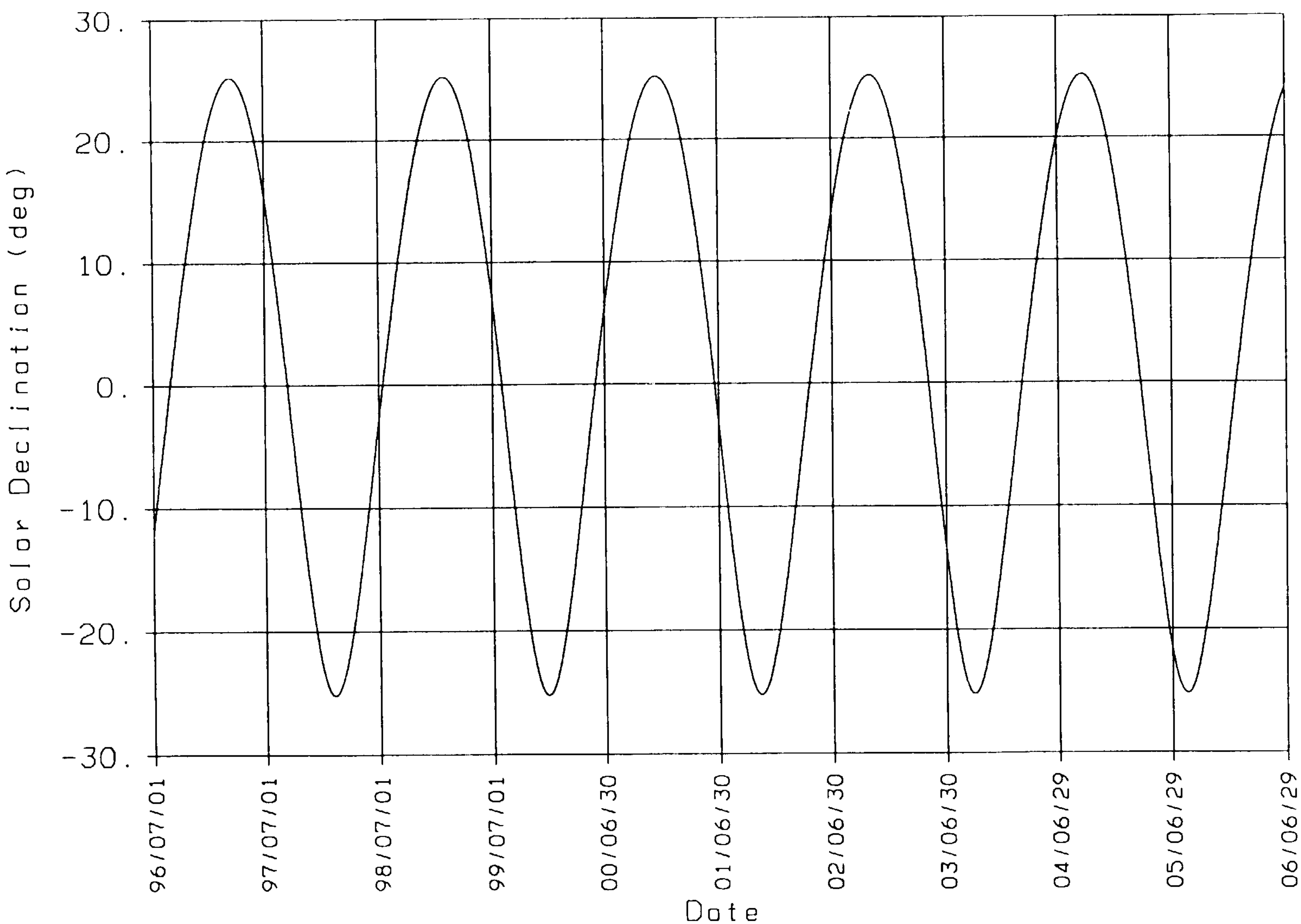
Solar Declination (1996-2006)



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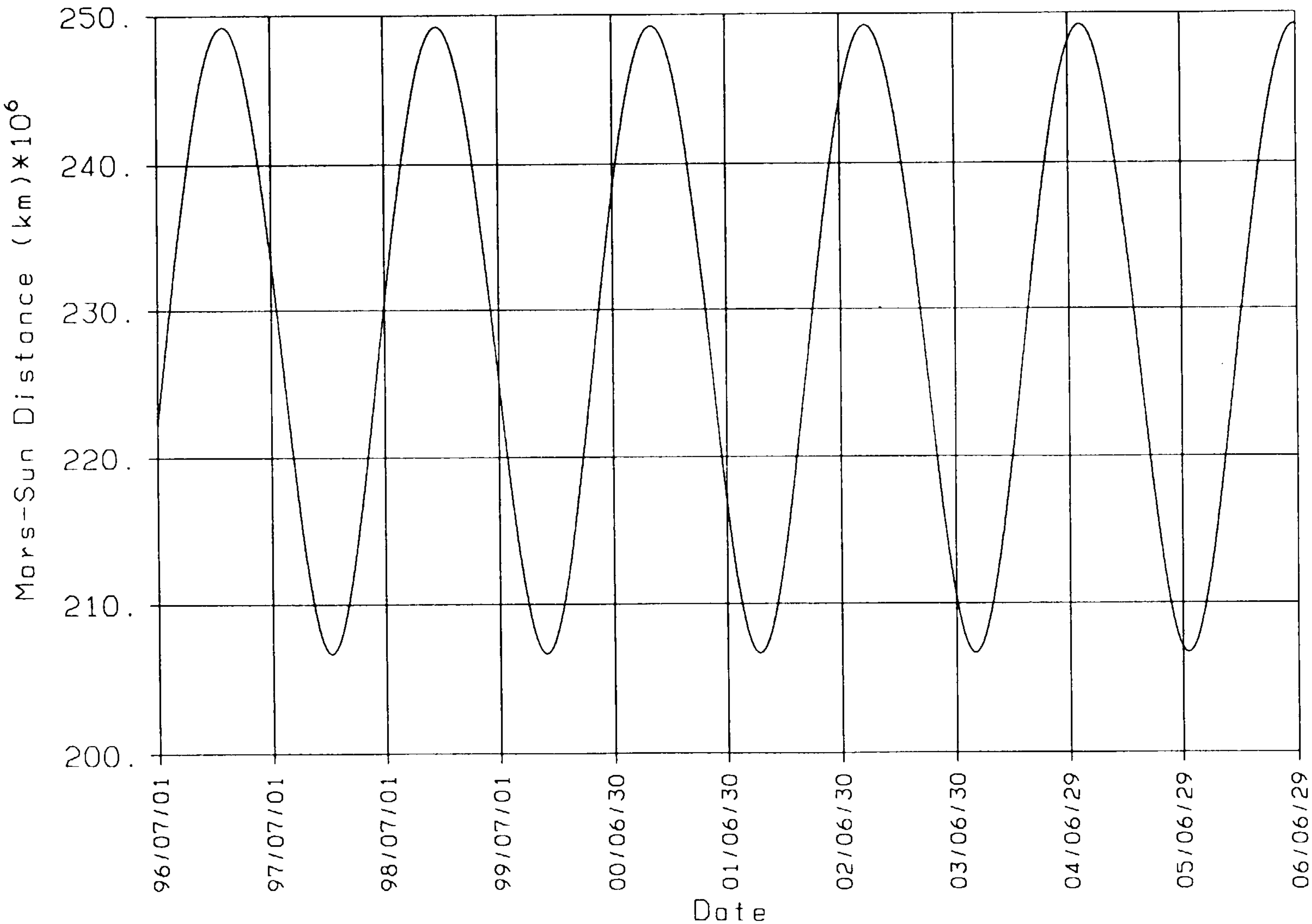
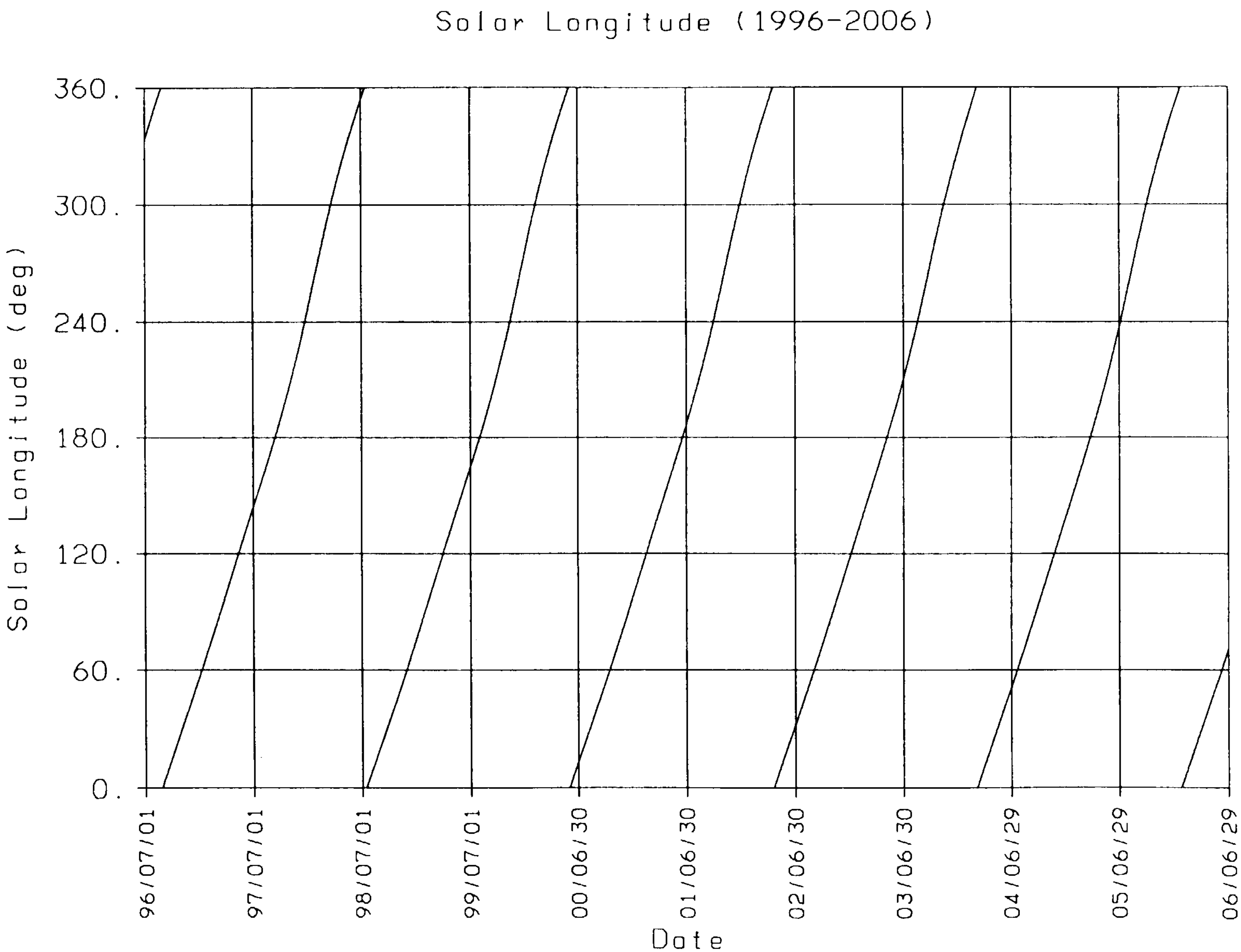
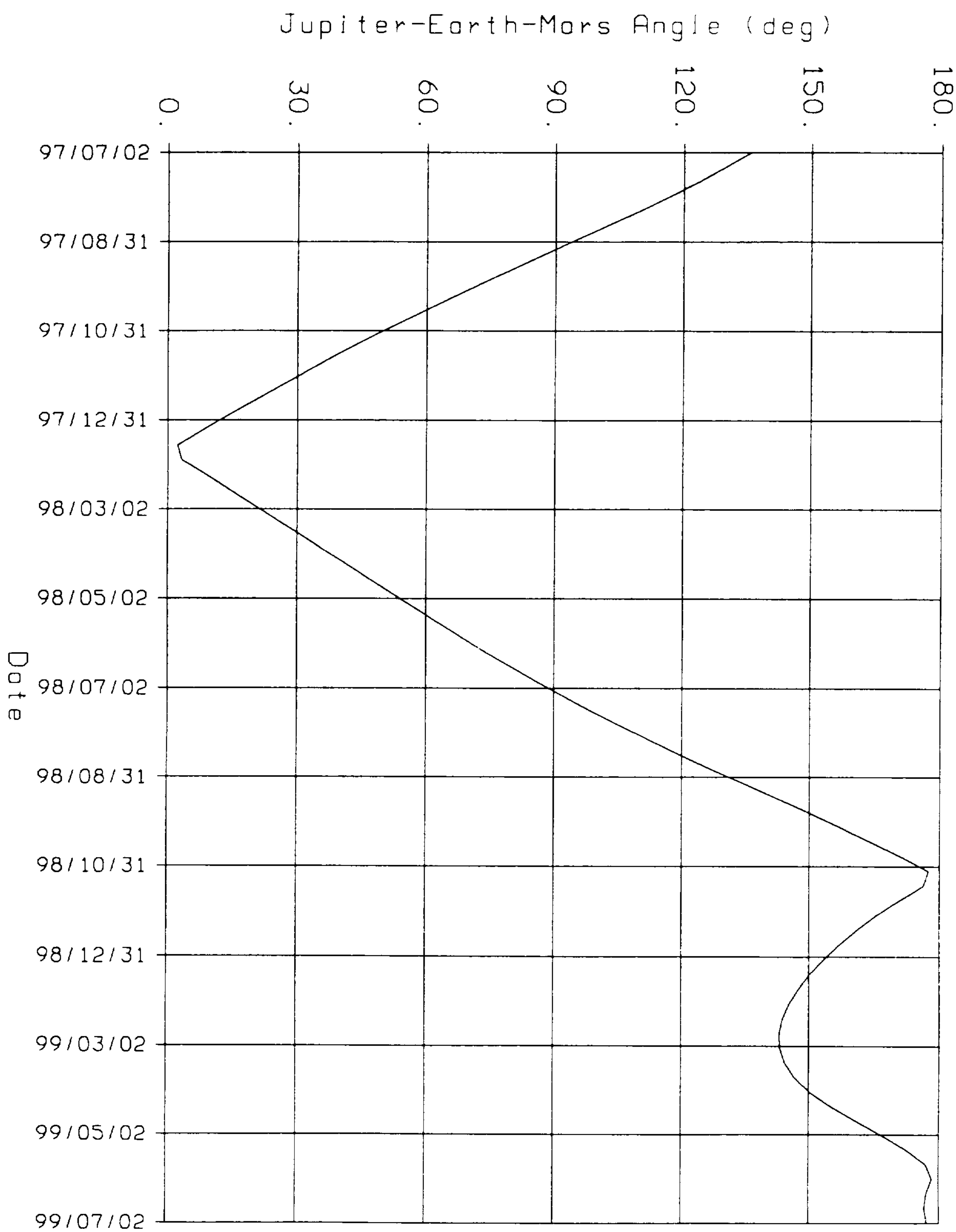
Sun-Mars Range (1996-2006)





Solar Longitude (1996-2006)
Solar Longitude (deg)
360.
300.
240.
180.
120.
60.
0.
96/07/01
97/07/01
98/07/01
99/07/01
00/06/30
01/06/30
02/06/30
03/06/30
04/06/29
05/06/29
06/06/29
Date



Jupiter-Earth-Mars Angle (deg)
0.
30.
60.
90.
120.
150.
180.
Date
97/07/02
97/08/31
97/10/31
97/12/31
98/03/02
98/05/02
98/07/02
98/08/31
98/10/31
98/12/31
99/03/02
99/05/02
99/07/02

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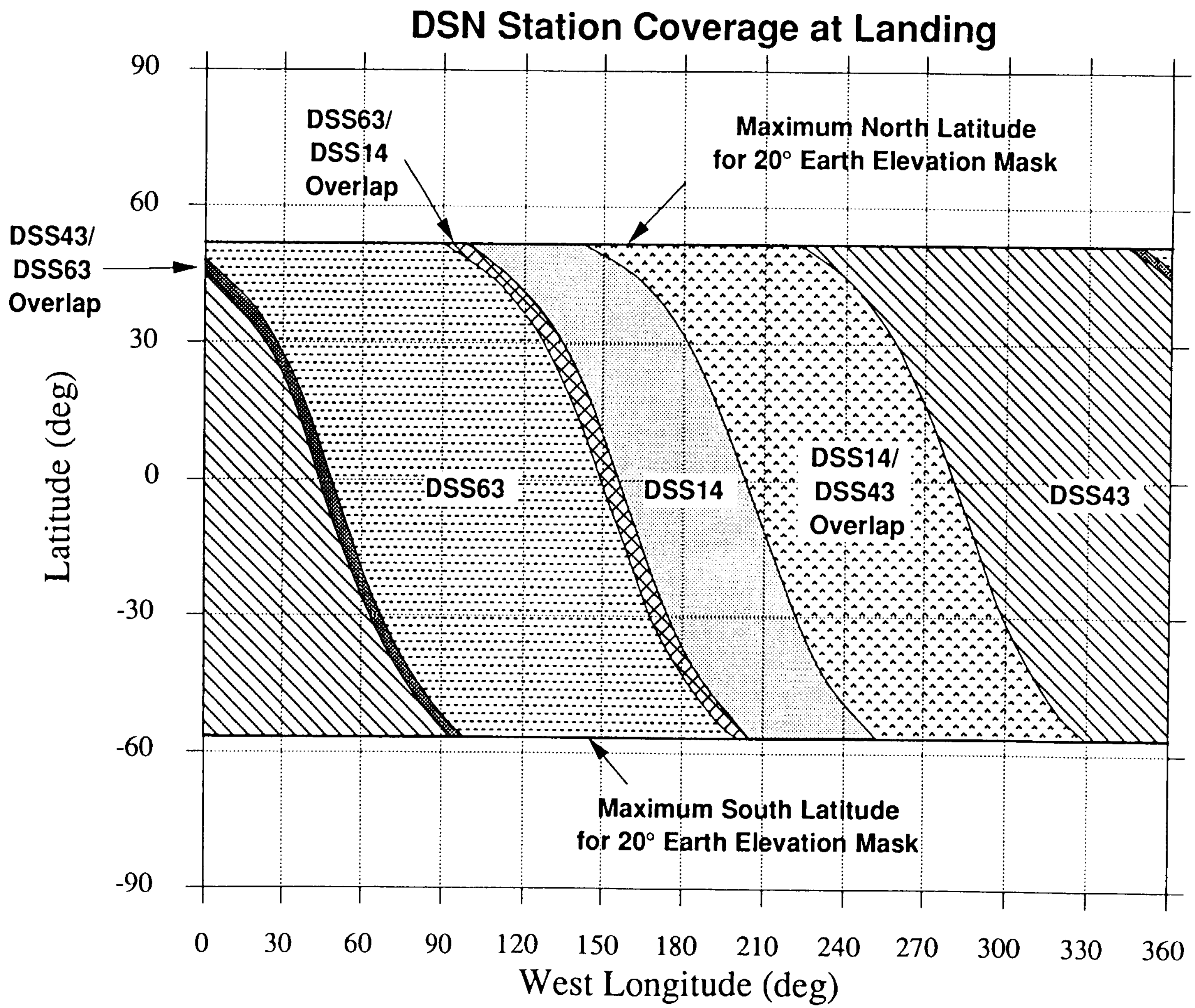
MESUR Pathfinder Reference Launch Period



1996 MESUR Pathfinder

Benefits for MESUR Network in Mission Design/Navigation Areas

- Mission/trajectory design process and tools used for Pathfinder apply directly to MESUR Network trajectory design; i.e., same process/tools, different dates
- Navigation software identical
- Navigation operations similar
  - Range and/or Doppler measurements are the primary data types
  - Maneuver strategy and implementation differs only in that MESUR Network may/will require additional Delta-V to separate lander arrival times
  - Possible proof of concept in operations of spacecraft-spacecraft VLBI data type which may reduce entry risk and provide improved lander targeting accuracy for MESUR Network
- Characterization of vehicle dynamics in flight which may affect entry risk and provide improved lander targeting
  - Solar radiation pressure model
  - Maneuver execution errors
  - Spinning vehicle nutation effects

1996 MESUR Pathfinder

Benefits for MESUR Network

- Coherent range and Doppler measurements to the landed vehicle will allow the development of an improved Martian ephemeris which may eliminate the need for operationally intense VLBI data types
- Atmospheric structure science will provide improved knowledge of the Martian atmosphere providing risk reduction and targeting accuracy benefits

MESUR NETWORK

Mission Description Topics

- Mission Overview
- Landing Site Considerations
- Trajectory Characteristics

JPL

Network Mission Overview

- Launch via Delta II during 1998-99, 2001, and 2003 Earth-Mars Opportunities
- Four free-flying aerocraft in each launch (1 launch in 1999 & 2001, 2 in 2003)
- Each aerocraft independently retargeted after launch to desired landing site
- Significant operational complexity due to four independent flight elements
- Maximum design inheritance from Pathfinder - especially in aeroshell and landing subsystems (spinning, ballistic, Viking-like aeroshell)
- Primary science objective is two years simutaneous operations of 16 element network for seismology, meteorology, and surface geochemistry
- Precise arrival site targeting capability required - complex navigation
- High latitude sites desirable ==> Implies communication orbiter and RTG's
- Communication Orbiter launch in 2001 (Ames Baseline) - Delta II launch
- Alternative mission scenarios possible without comm orbiter or with compressed launch schedule

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Landing Site Availability

- Strawman Landing Site List
  - + 1999
    - Valles Marineris (6°S,58°W) - 70° Solar Elevation Angle
    - Valles Marineris (5°S,54°W) - 70° Solar Elevation Angle
    - VL-1 Site (23°N,48°W) - 35° Solar Elevation Angle
    - Olympus Mons (13°N,130°W) - 50° Solar Elevation Angle
  - + 2001
    - Oldest Plateau (2°S,54°W) - 65° Solar Elevation Angle
    - Nothern Plains (60°N,50°W) - Not Achievable
    - Hellas (40°S,310°W) - Not Desired, 65° Solar Elevation Angle
    - Polar (90°S,-) - Not Achievable
  - + 2003
    - Ancient Argyre Rim (44°S,55°W) - 45° Solar Elevation Angle (N Launch)
    - Noachian Plateau (44°S,120°W) - 45° Solar Elevation Angle (N Launch)
    - Tyrrena Patera (21°S,254°W) - 70° Solar Elevation Angle (S Launch)
    - Lacustrine Deposits (15°S,185°W) - 75° Solar Elevation Angle (S Launch)
    - Syrhis Major (5°N, 295°W) - 60° Solar Elevation Angle (N Launch)
    - N. Arabia (38°N,309°W) - 45° Solar Elevation Angle(S Launch)
    - Chasma Borealis (82°N,55°W) - -15° Solar Elevation Angle (N Launch)
    - Polar Plains (66°S, 66°W) - 25° Solar Elevation Angle (S Launch)

- Shifting High Latitude Sites From 2001 to 2003 Would Allow All Sites to be Achieved

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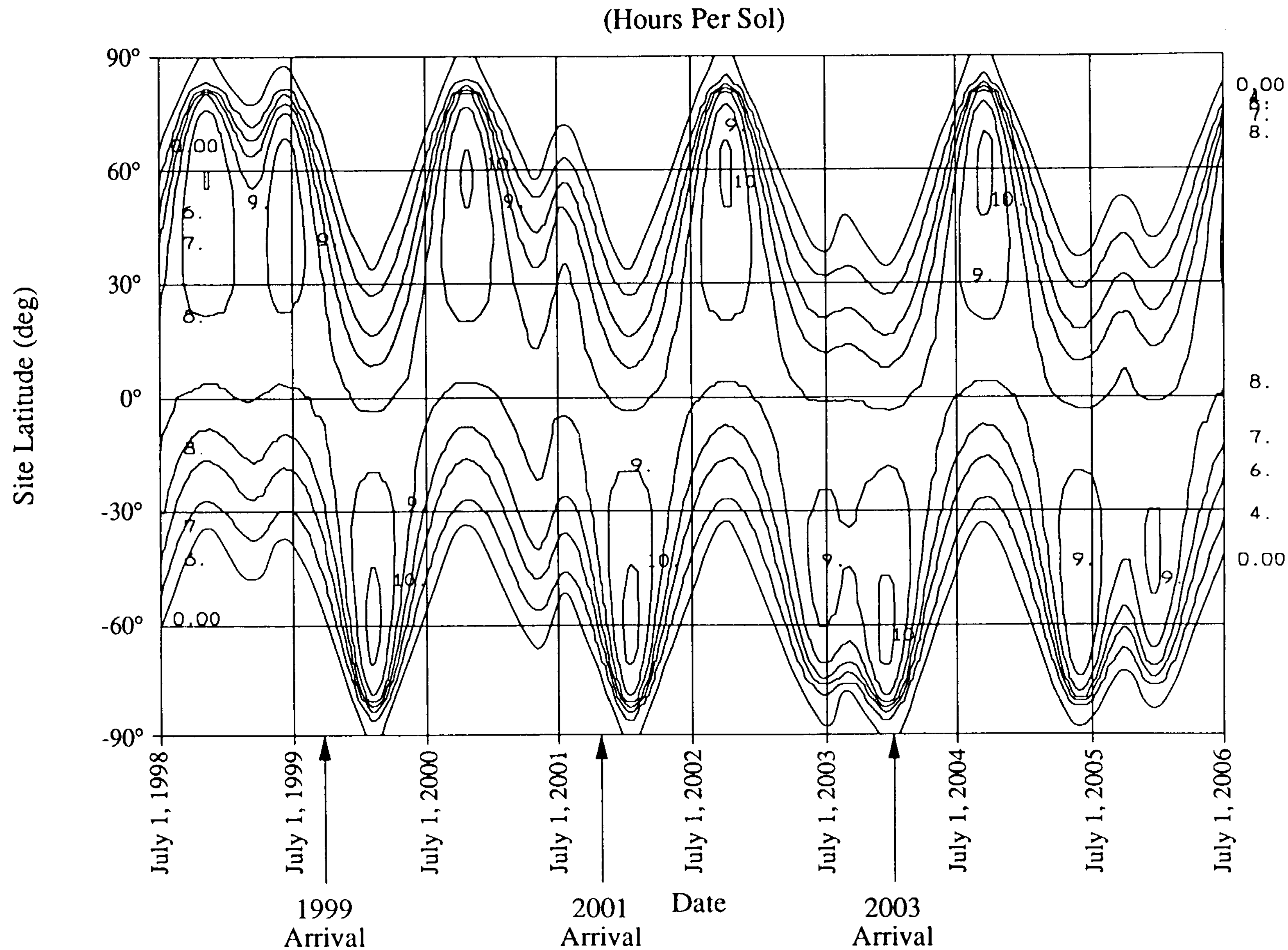
EARTH OBSERVABILITY VARIATIONS
1998-2006 (30° MASK)



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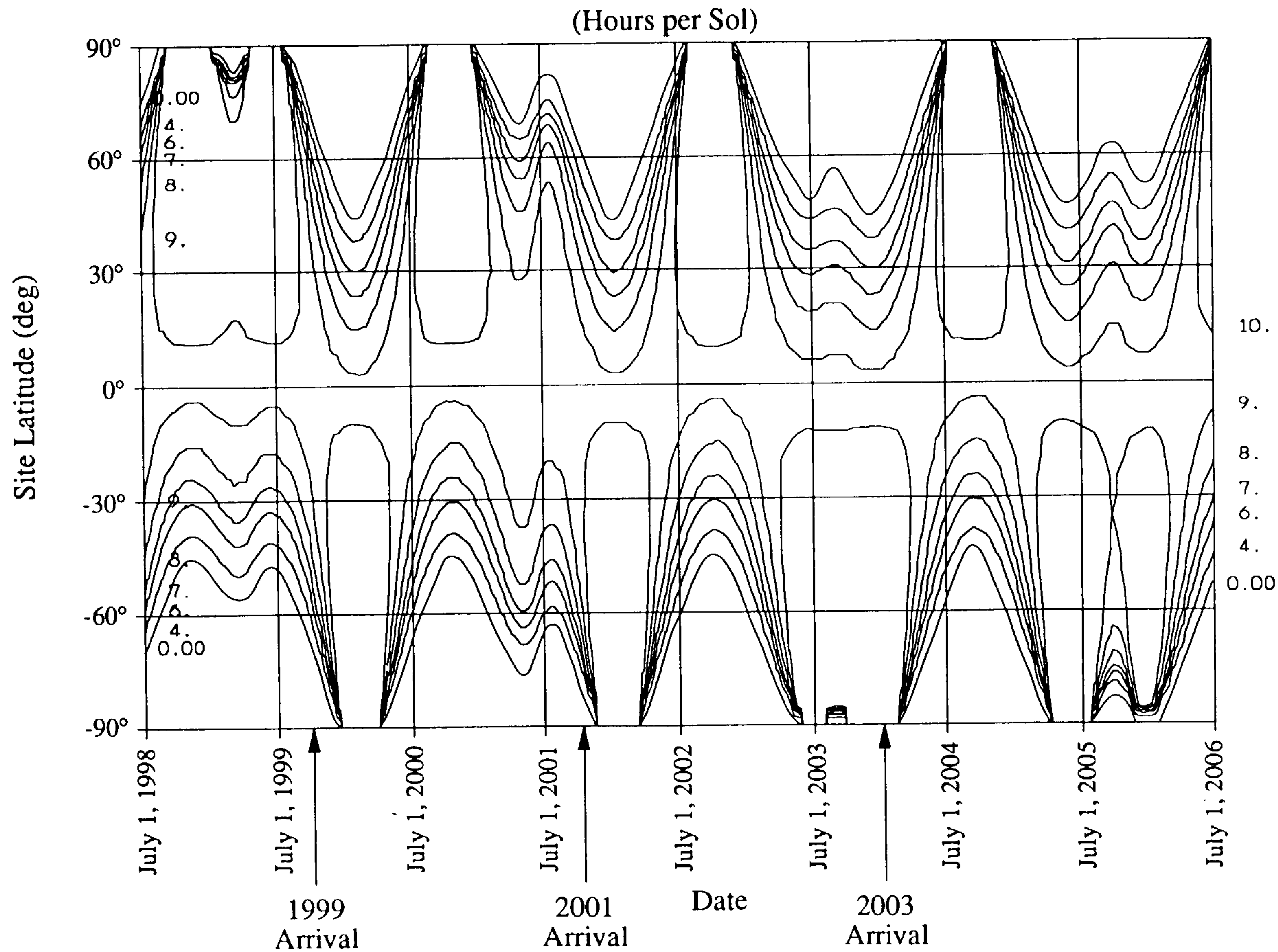
EARTH OBSERVABILITY VARIATIONS 1998-2006 (20° MASK)



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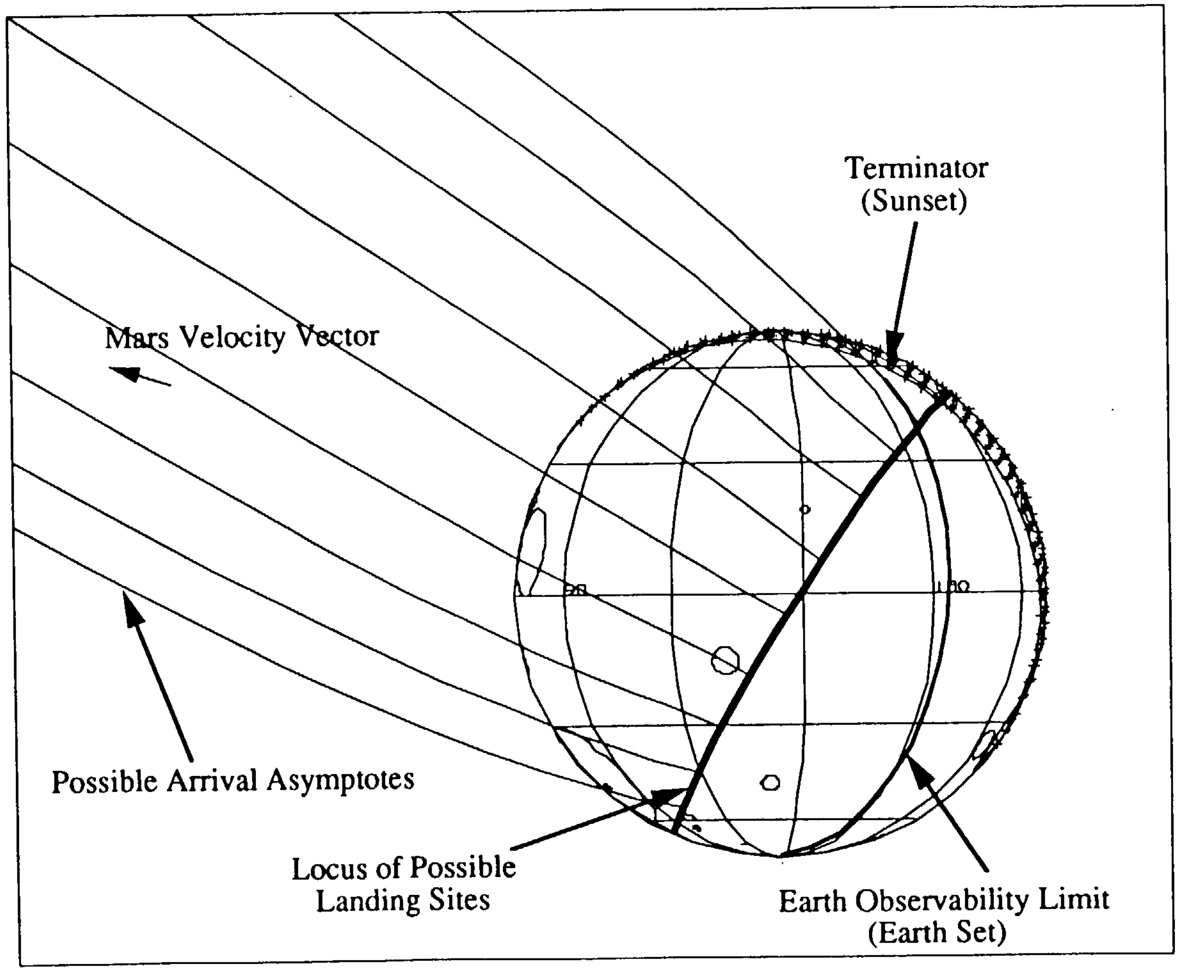
MESUR 1999 Reference Launch Period

Reference Launch Period Data

Launch Date	Arrival Date	Launch C3 (km2/s2)	Launch Declination	Arrival Declination	V-infinity (km/s)	V-entry (km/s)
12/6/98	9/30/99	11.63	10.70°	-28.81°	3.38	5.98
12/15/98	9/30/99	10.28	17.53°	-32.30°	3.37	5.97
12/25/98	9/30/99	10.64	28.93°	-38.59°	3.46	6.02

MESUR 1999 Reference Launch Period



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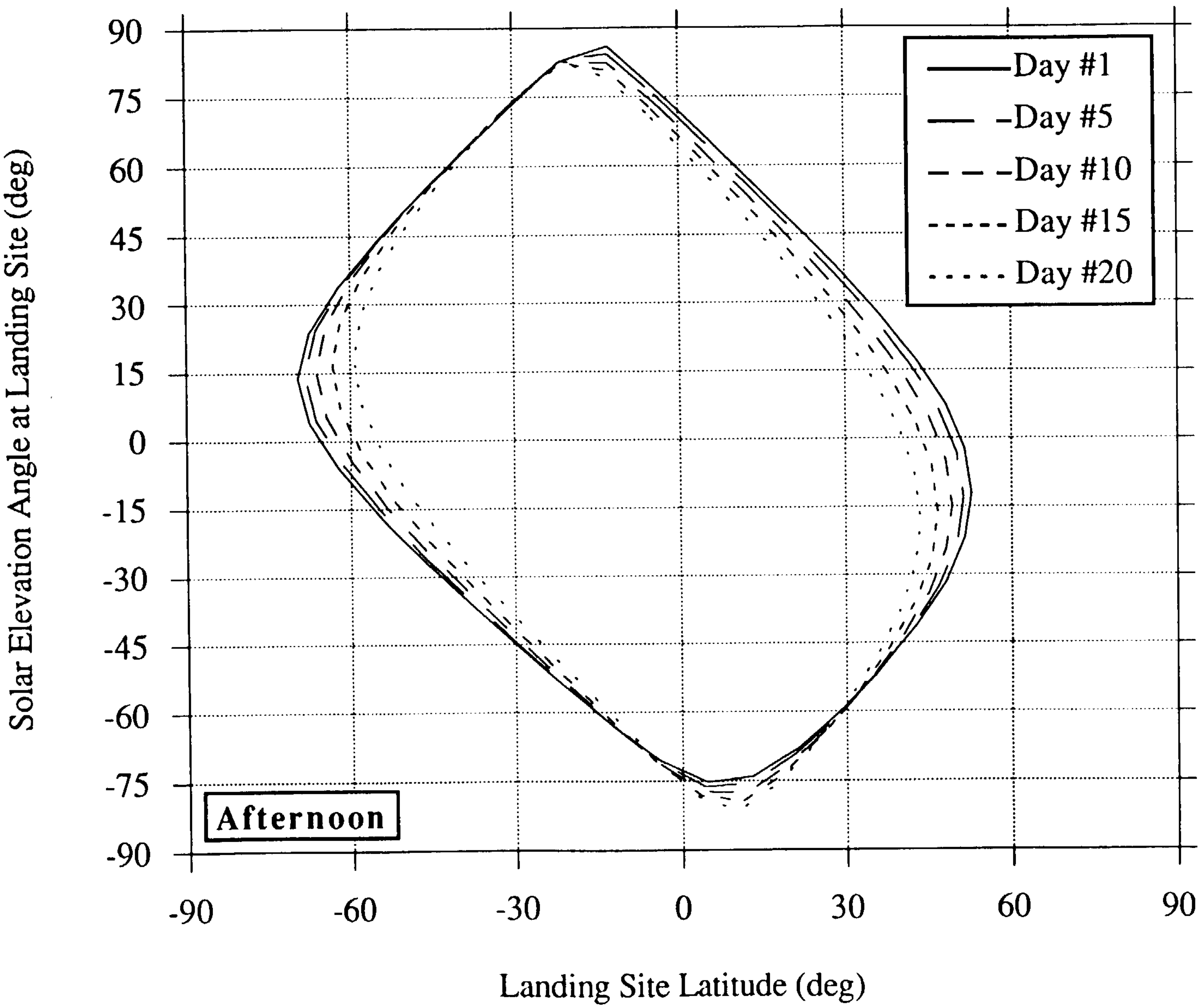
MESUR 1999 Reference Launch Period



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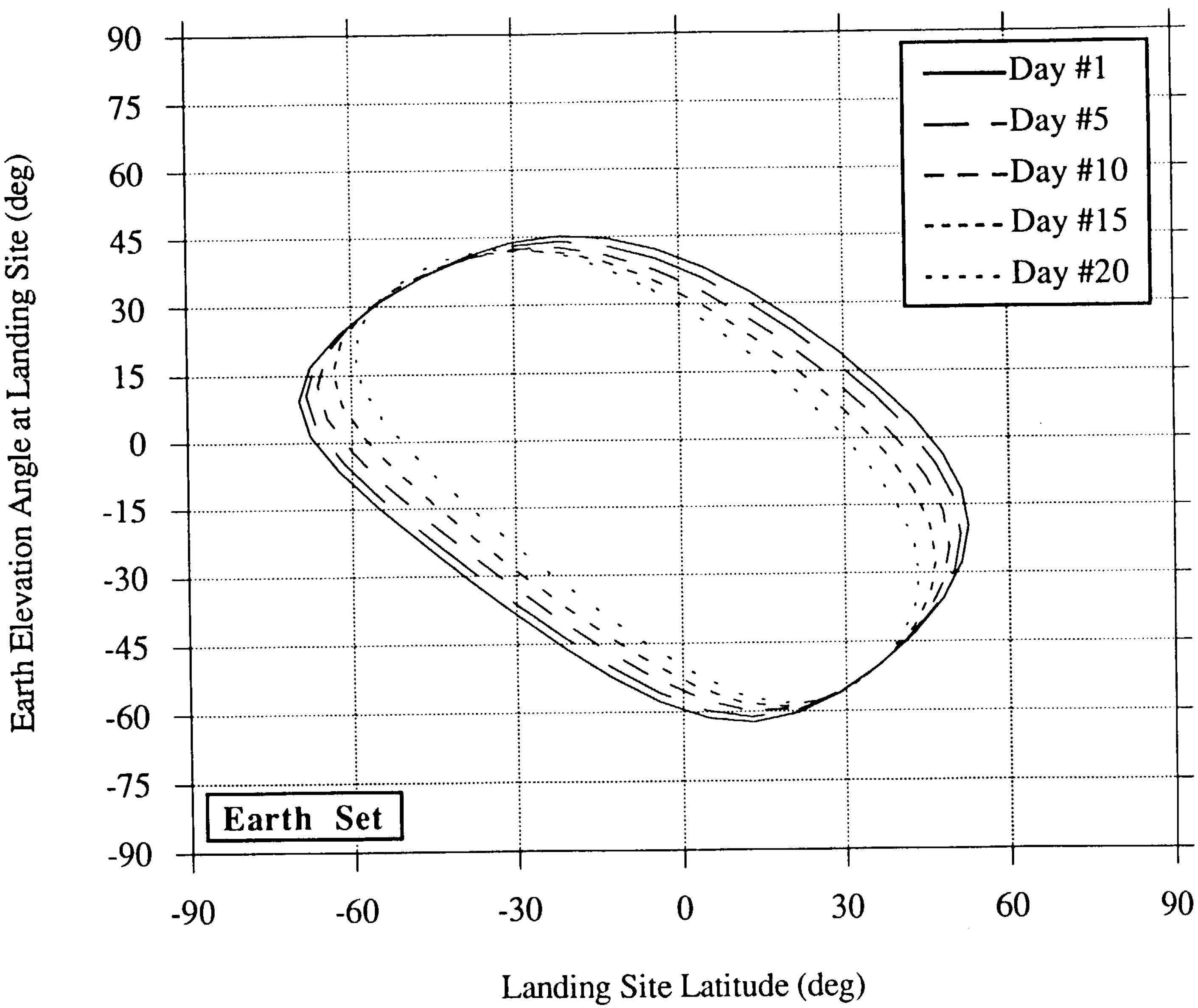
MESUR 1999 Reference Launch Period



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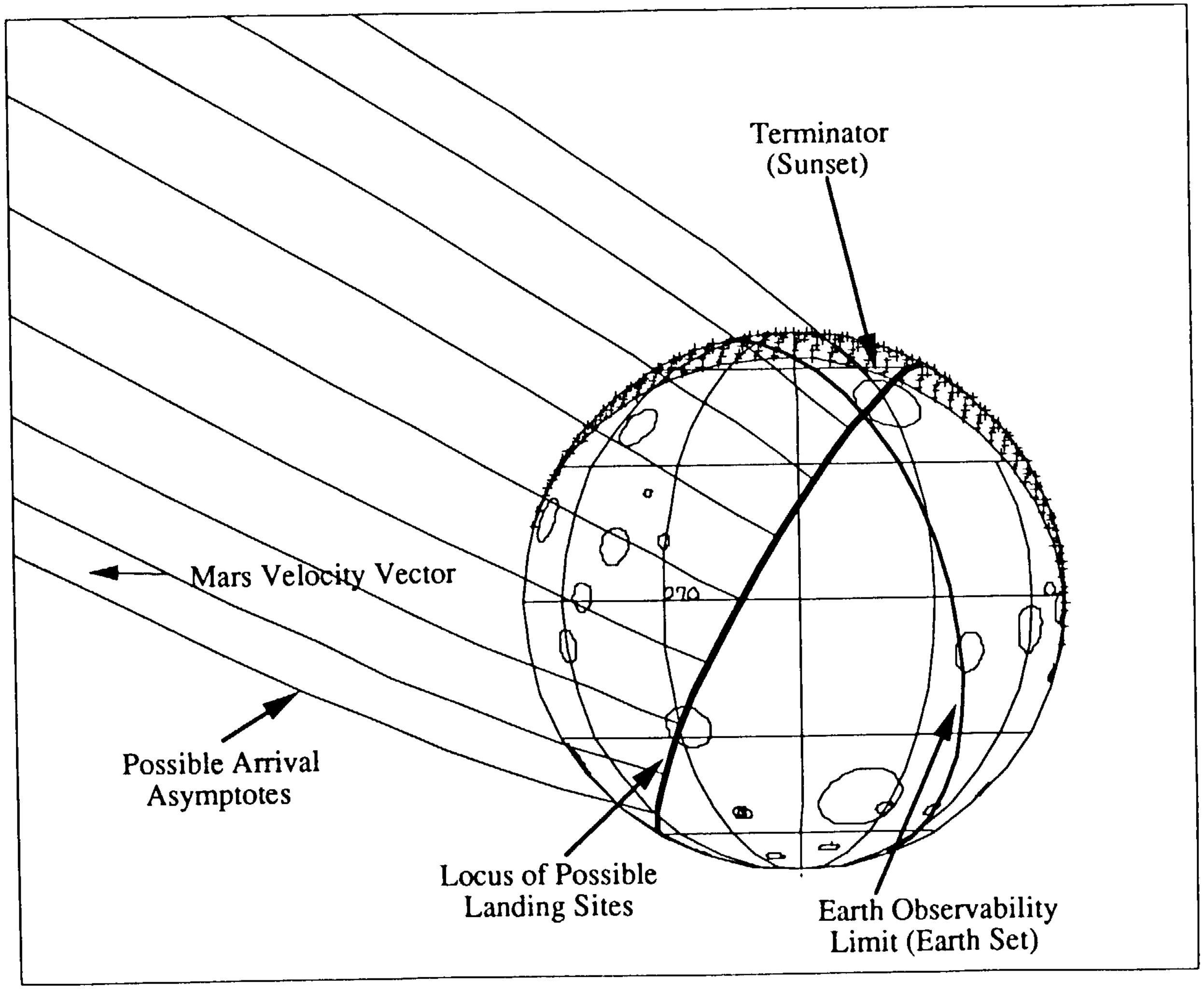
MESUR 2001 Reference Launch Period

Reference Launch Period Data

Launch Date	Arrival Date	Launch C3 (km2/s2)	Launch Declination	Arrival Declination	V-infinity (km/s)	V-entry (km/s)
1/28/01	11/01/01	13.87	-1.16°	-26.20°	3.92	6.30
2/6/01	11/01/01	12.60	6.56°	-29.31°	3.92	6.30
2/16/01	11/01/01	13.76	20.36°	-35.44°	4.13	6.43

MESUR 2001 Reference Launch Period



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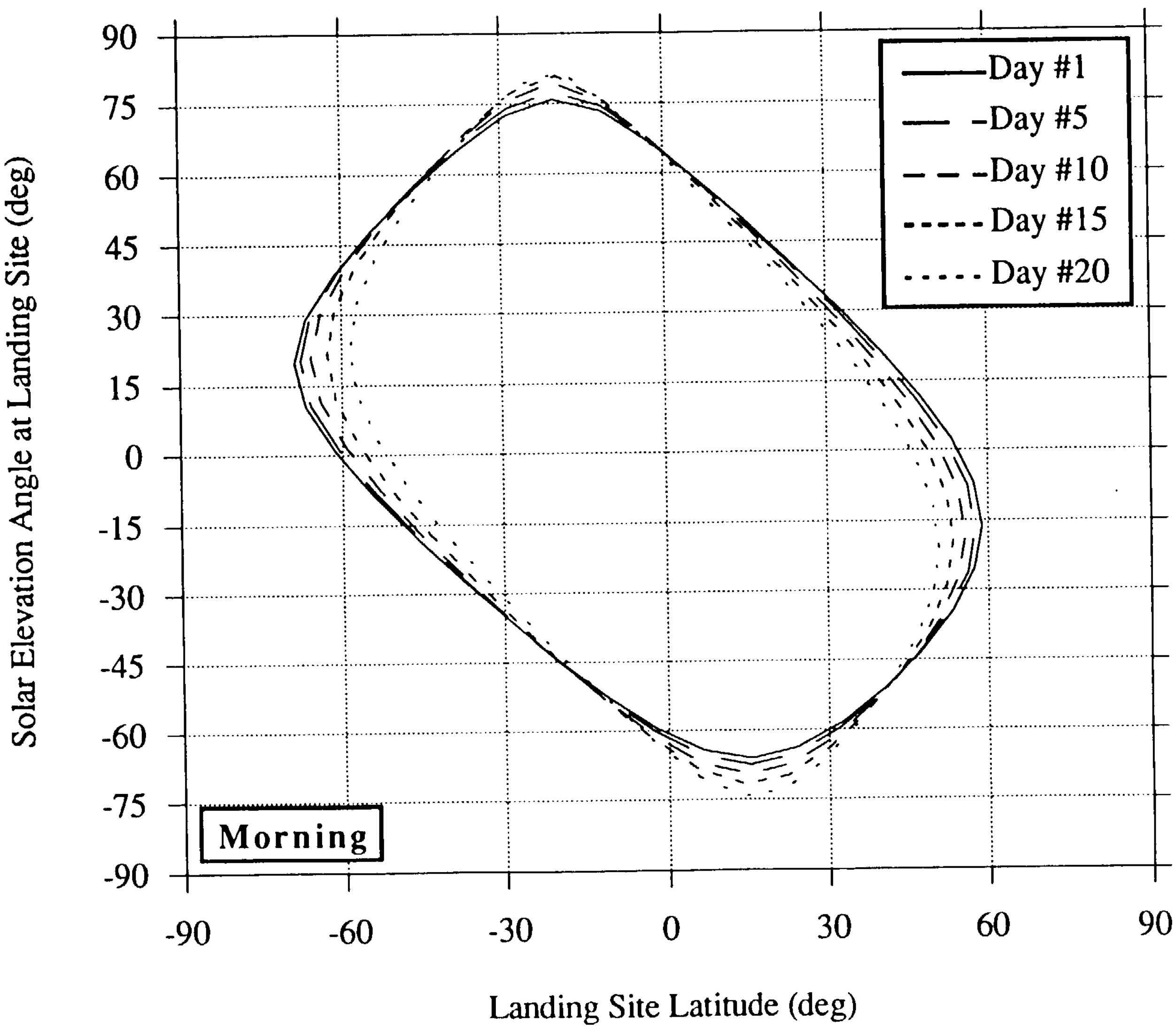
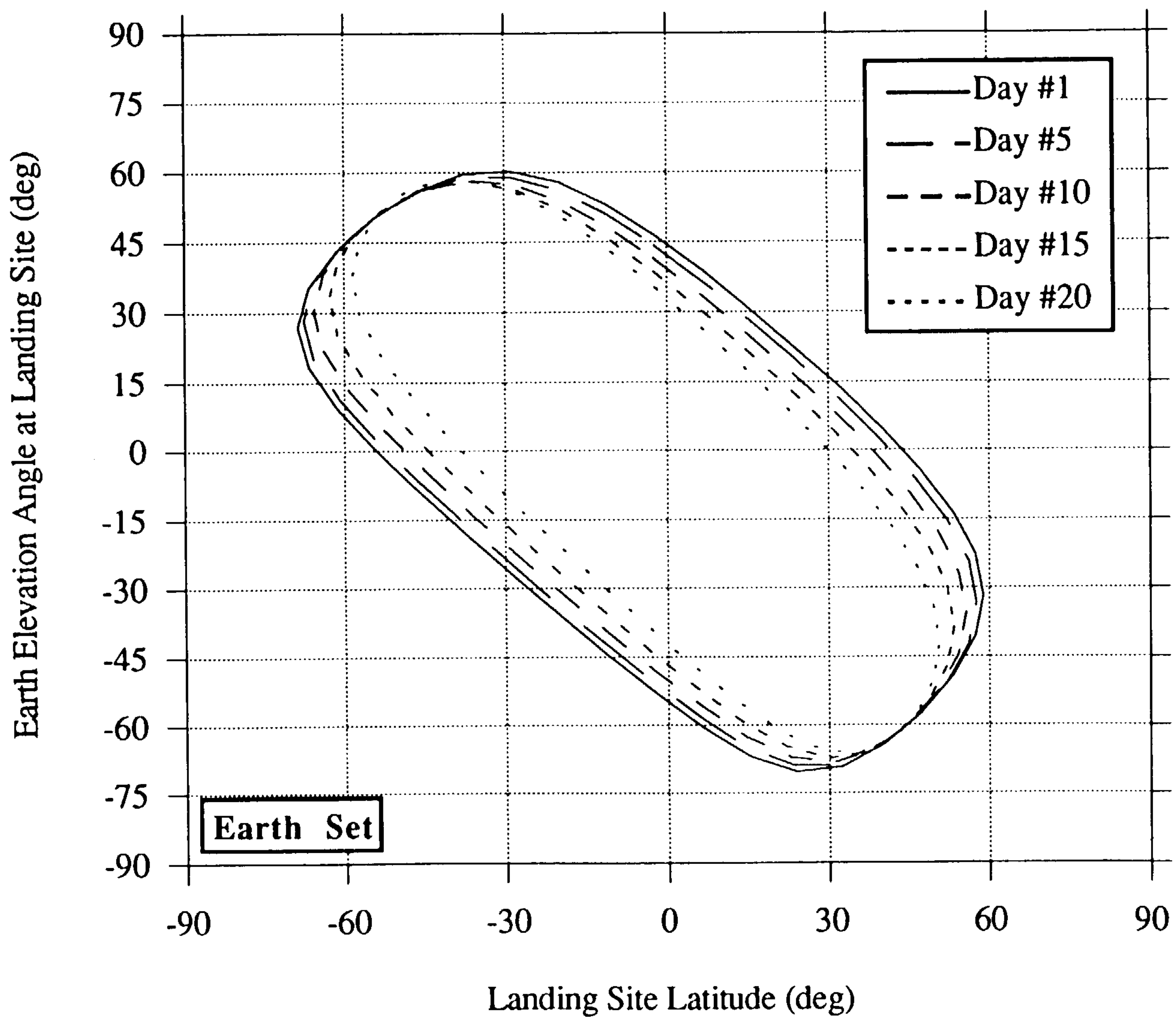
MESUR 2001 Reference Launch Period



MESUR 2001 Reference Launch Period



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MESUR 2003 Reference Launch Periods

Northern Hemisphere Bias Launch Period Data

Launch Date	Arrival Date	Launch C3 (km2/s2)	Launch Declination	Arrival Declination	V-infinity (km/s)	V-entry (km/s)
5/14/03	12/18/03	11.35	-11.77°	13.41°	2.74	5.64
5/23/03	12/10/03	9.77	-11.57°	13.18°	2.80	5.67
6/2/03	12/08/03	9.04	-12.03°	12.47°	2.86	5.70

Southern Hemisphere Biased Launch Period Data

Launch Date	Arrival Date	Launch C3 (km2/s2)	Launch Declination	Arrival Declination	V-infinity (km/s)	V-entry (km/s)
6/13/03	2/01/04	11.04	19.12°	-9.36°	3.14	5.85
6/22/03	2/12/04	11.91	18.94°	-8.92°	3.20	5.88
7/2/03	2/26/04	13.93	18.86°	-8.14°	3.31	5.94

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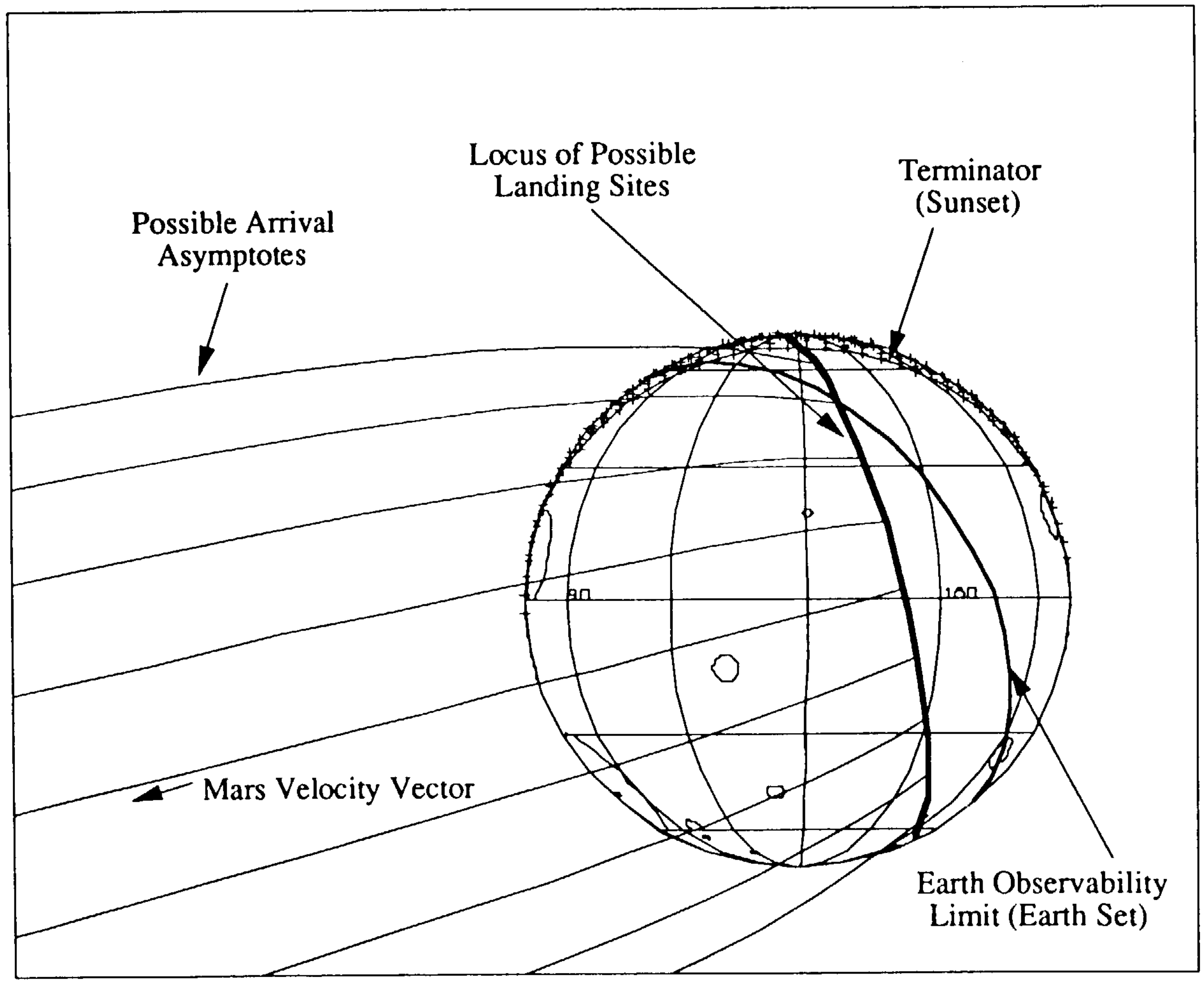
2003 Earth-Mars Reference Trajectory

Northern Hemisphere Biased



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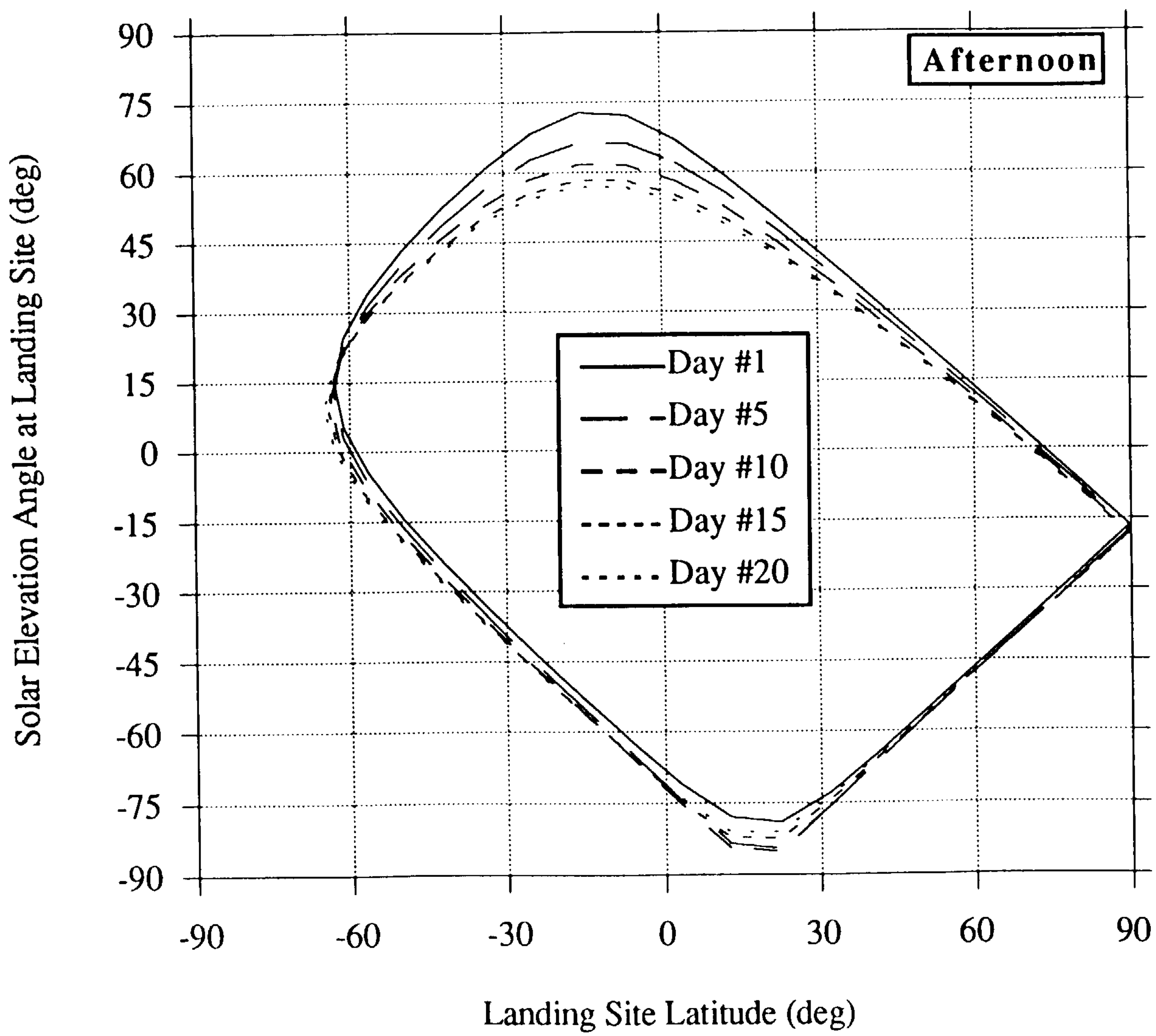
Earth-Mars 2003 Reference Launch Period

Northern Hemisphere Landing Bias



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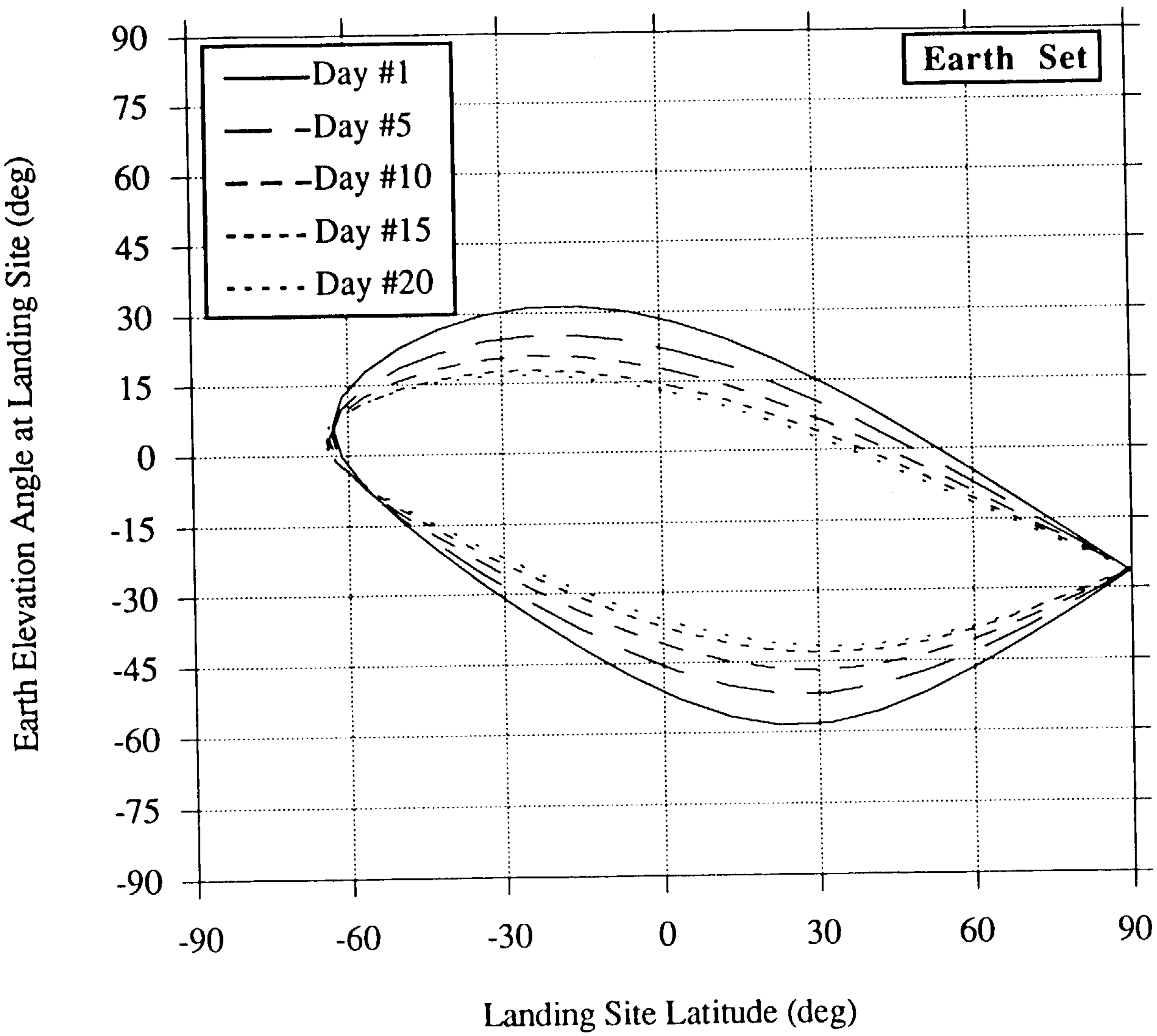
Earth-Mars 2003 Reference Launch Period

Northern Hemisphere Landing Bias



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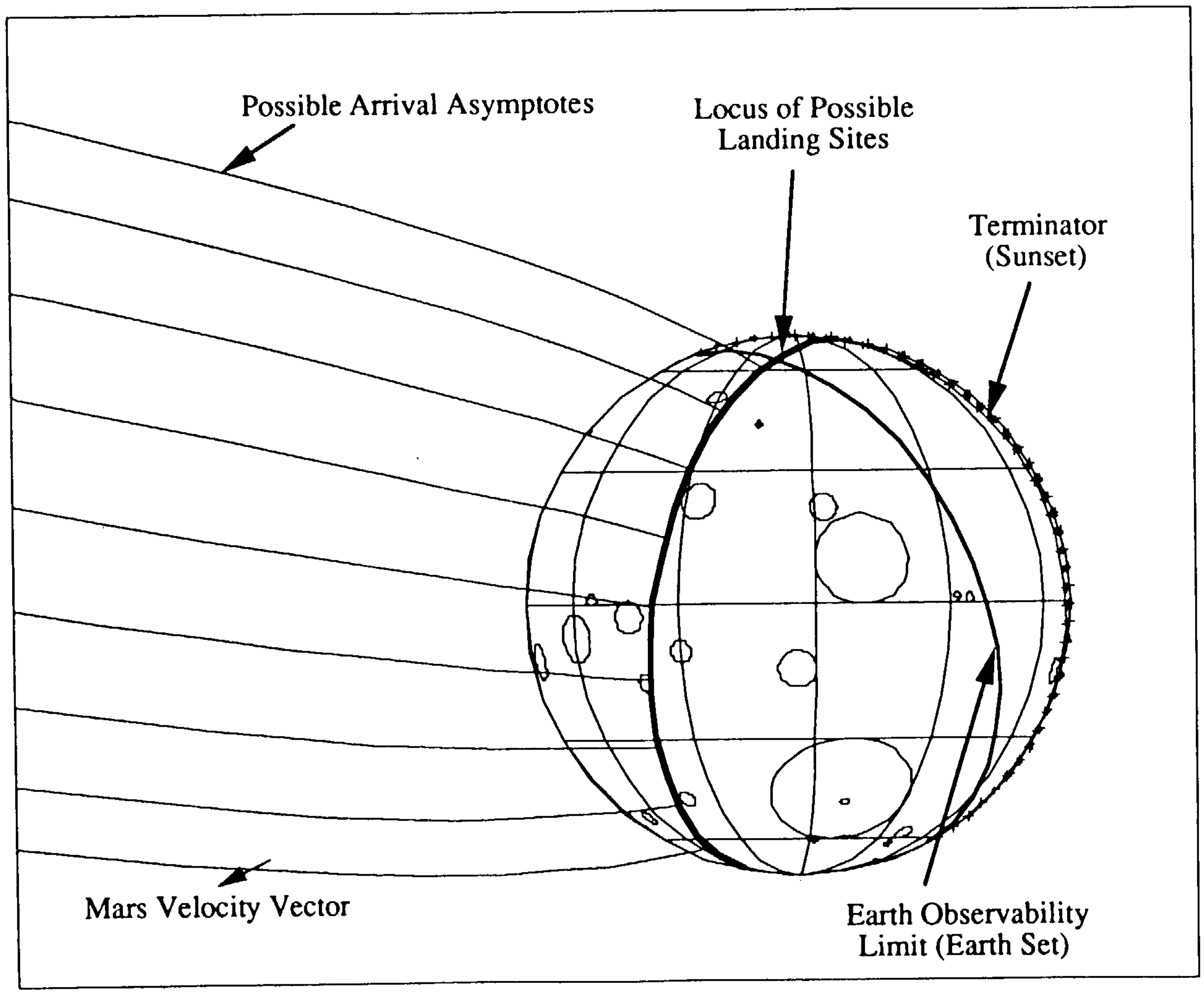
MESUR 2003 Reference Launch Period
Southern Hemisphere Landing Bias



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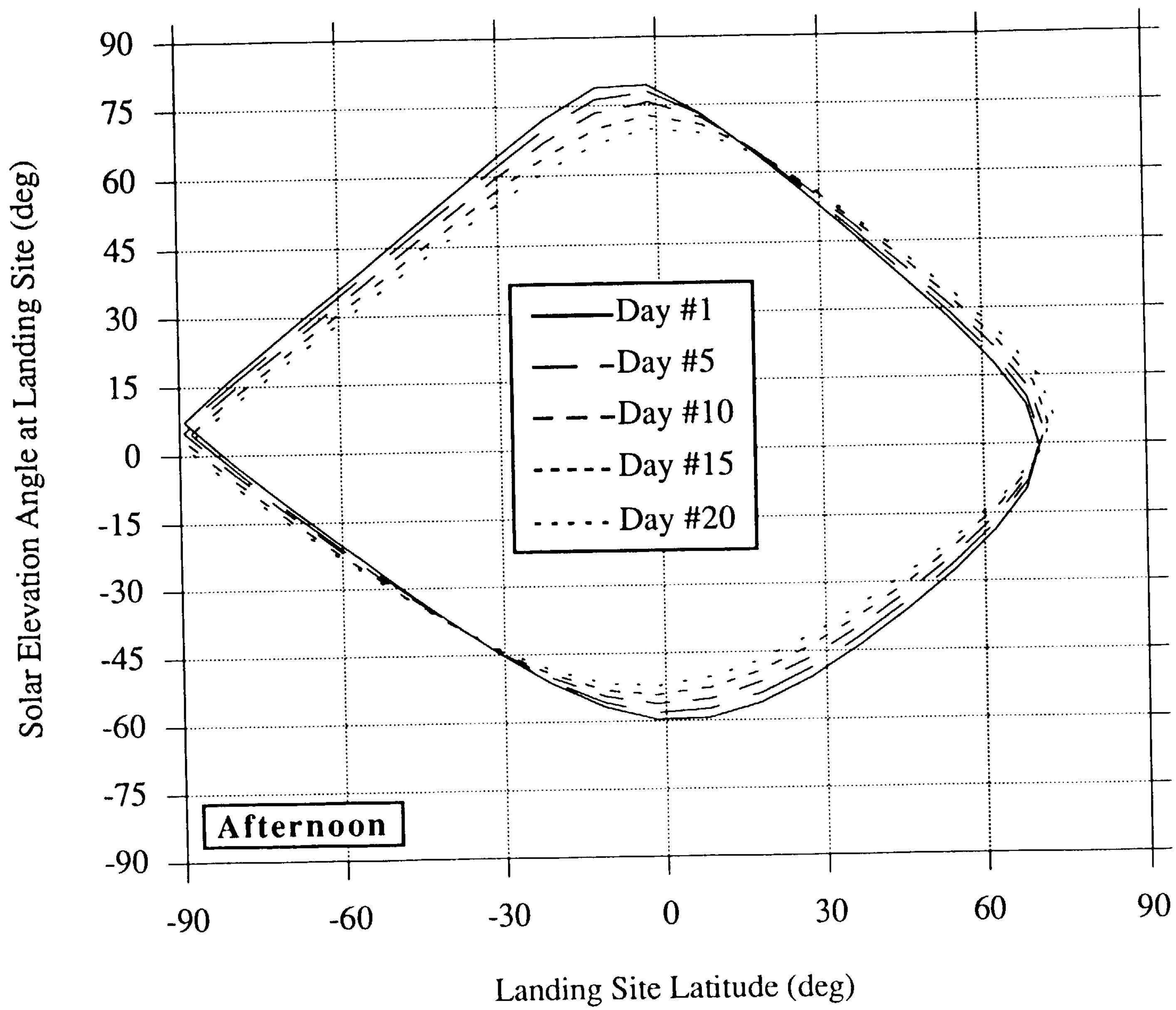
MESUR 2003 Reference Launch Period

Southern Hemisphere Landing Bias



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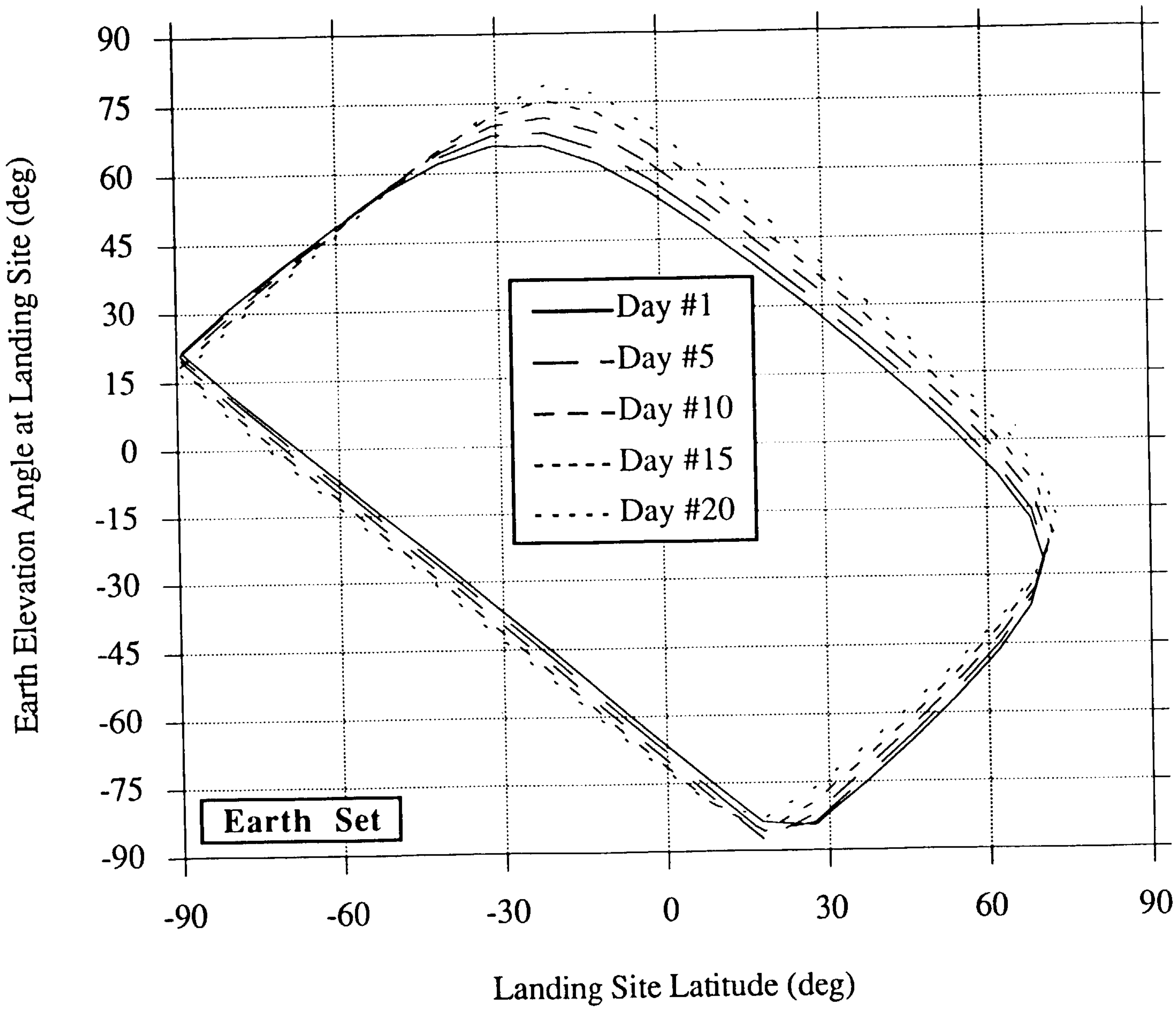
MESUR 2003 Reference Launch Period

Southern Hemisphere Landing Bias



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MARS SCIENCE WORKING GROUP MEETING

MESUR PATHFINDER FLIGHT SYSTEM STATUS

DAVID H. LEHMAN

17 JUNE 1992

MESUR PATHFINDER FLIGHT SYSTEM STATUS
AGENDA

OVERVIEW

BUSINESS APPROACH

TECHNICAL CANDIDATES/OPTIONS FOR PRELIMINARY DESIGN

NEW TERM SCHEDULE

BACK UP CHARTS

MESUR PATHFINDER FLIGHT SYSTEM STATUS
OVERVIEW

- PROGRAMMATICS
  - IMPLEMENTATION PLANNING IN PROCESS
  - APPROACH TARGETING THE HIGHLY COST-CONSTRAINED ENVIRONMENT
  - USING DESIGN-TO-COST IN CONCEPTUAL DESIGN PROCESS
    - COST ALLOCATIONS
    - COST / CAPABILITY VERIFICATION
      - JPL AND SAIC MODELS
      - JPL DIVISION-SUPPORTED PLANS
- CONCEPTUAL DESIGN
  - QUICK POINT-DESIGN EXERCISE RESULTS PRESENTED 4/13/92
  - BROAD RANGE OF DESIGN OPTIONS UNDER CONSIDERATION SINCE THEN
    - MOST WORK IS CONCENTRATING ON THE DELIVERY FUNCTION -- EMPHASIS IS INVERSE WITH DISTANCE TO MARS SURFACE, I.E.:
      - LANDING PHASE [HIGHEST]
      - TERMINAL DESCENT PHASE
      - EARLY DESCENT PHASE (WITH PARACHUTE)
      - ENTRY PHASE (WITH AEROSHELL HEAT SHIELD)
      - CRUISE PHASE
      - LAUNCH PHASE
    - WORK ALSO CONTINUES IN THE OTHER KEY FUNCTIONAL AREAS: (POWER & TEMPERATURE CONTROL, COMMUNICATIONS, ATTITUDE & INFORMATION CONTROL, PROPULSION, AND STRUCTURE/DEVICES/CABLING)
  - OPTION RANGE TO BE REDUCED BEFORE COST / CAPABILITY VERIFICATION ANALYSIS (WITH FURTHER REDUCTION / CONSOLIDATION AFTER ANALYSIS)

MESUR PATHFINDER FLIGHT SYSTEM STATUS
BUSINESS APPROACH

- CUSTOMER DESIRES JPL TO PRODUCE LESS EXPENSIVE, QUICK REACTION SPACE PROJECTS
- JPL MANAGEMENT DESIRES TO DEVELOP APPROACH TO IMPLEMENT LESS EXPENSIVE SPACE PROJECTS TO TAKE ADVANTAGE OF "GROWING MARKET" IN "SMALL SPACECRAFT"
- PROJECT, WORKING WITH VARIOUS ORGANIZATIONS, NEEDS TO EXPLORE METHODS TO MEET THESE NEEDS:
  - USE EXISTING DESIGNS WHERE POSSIBLE
  - STREAMLINE MANAGEMENT APPROACH - EMPOWER COG E's/TECHNICAL MANAGER WITH AUTHORITY TO CARRY OUT RESPONSIBILITIES
  - PUSH DECISION MAKING PROCESS TO THE LOWEST LEVEL DEEMED ADEQUATE
  - USE "DESIGN TO COST" METHODS
  - CONSTRAIN SCIENCE TO OBJECTIVES THAT FALL WITHIN THE COST GOALS
  - MINIMIZE FORMALITIES OF REPORTING
- USE SIMPLE DESIGNS THAT MINIMIZE INTERFACES BETWEEN SUBSYSTEMS
  - GIVE FLIGHT SYSTEM DESIGN TEAM BOTH DESIGN AND IMPLEMENTATION RESPONSIBILITY
  - COMBINE SUBSYSTEMS WHERE DESIRABLE (I.E. COMBINE AACS/CDS FUNCTIONS INTO ONE)
  - KEEP DESIGN SIMPLE ENOUGH TO ELIMINATE NEED FOR EXTRA LEVELS OF MANAGEMENT (E.G. DIVISION/PROJECT REPS)

MESUR PATHFINDER FLIGHT SYSTEM STATUS
BUSINESS APPROACH (cont'd)

- INTERACT PERIODICALLY WITH DIVISION/SECTION MANAGERS TO ENSURE THEY ARE ON THE "MESUR TEAM"
- PROJECTIZE/CO-LOCATE TEAMS TO STREAMLINE MANAGEMENT WHERE BENEFICIAL
- MESUR "DESIGN-TO-COST" APPROACH
    - BASED ON SUBSYSTEM ALLOCATIONS
    - DESIGN AND IMPLEMENTATION APPROACH EVOLVES THROUGHOUT COSTING EXERCISE
- DEVELOP MESUR METHOD FOR "INCENTIVES FOR COST CONTROL"

MESUR PATHFINDER FLIGHT SYSTEM STATUS

TELECOMMUNICATIONS, POWER, AND TEMPERATURE CONTROL

CANDIDATES / OPTIONS FOR PRELIMINARY DESIGN

- TELECOMMUNICATIONS
  - X-BAND DIRECT LINK WITH SWITCHED, BODY-MOUNTED ANTENNAS
    - S-BAND IS A POSSIBLE ALTERNATIVE
- POWER
  - PROBABLY BODY-MOUNTED SOLAR ARRAYS FOR CRUISE AND SURFACE OPERATIONS
    - ALSO CONSIDERING JUST BATTERIES FOR [BRIEF] SURFACE OPERATIONS
    - RTG USE IS UNLIKELY PRIMARILY DUE TO COST
- TEMPERATURE CONTROL - ENERGY FOR SURFACE OPERATIONS
  - PROBABLY SOLAR ARRAY ELECTRICAL POWER
    - POSSIBLE ADDITIONAL ENERGY FROM RHUs
    - RTG USE IS UNLIKELY (AS ABOVE)
- TEMPERATURE CONTROL - DAY/NIGHT ENERGY STORAGE
  - BATTERIES PROBABLY PROVIDE PART OF ENERGY STORAGE NEEDS
  - ADDITIONAL STORAGE MAY BE PROVIDED WITH PHASE CHANGE MATERIAL

MESUR PATHFINDER FLIGHT SYSTEM STATUS
ATTITUDE AND INFORMATION CONTROL AND PROPULSION
CANDIDATES / OPTIONS FOR PRELIMINARY DESIGN

- ATTITUDE AND INFORMATION CONTROL
  - SPIN-STABILIZED DURING CRUISE AND ENTRY
    - WITH SUN AND STAR SENSORS
  - SPINNING FOR TERMINAL DESCENT
    - WITH ALTITUDE SENSOR
    - WITH HORIZONTAL VELOCITY SENSOR IF H-DECELERATION IS UTILIZED
    - POSSIBLE 2- OR 3-AXIS CONTROL FOR TERMINAL DESCENT DECELERATION
  - ATTITUDE DETERMINATION ON MARS SURFACE
    - WITH SUN SENSOR AND TILT METER
  - PROBABLY CENTRALIZED 1750 COMPUTER WITH 140 MBIT OF SOLID-STATE MEMORY
- PROPULSION
  - MONOPROPELLANT HYDRAZINE
    - WITH 2 PROPELLANT TANKS
    - WITH SMALL THRUSTERS FOR ATTITUDE CONTROL
    - WITH LARGE THRUSTERS FOR TERMINAL DECELERATION IF UTILIZED

MESUR PATHFINDER FLIGHT SYSTEM STATUS
LAUNCH, CRUISE, ENTRY, AND EARLY DESCENT
CANDIDATES / OPTIONS FOR PRELIMINARY DESIGN

- LAUNCH PHASE (LAUNCH AND INJECTION)
    - PROBABLY DELTA II LAUNCH VEHICLE FAMILY (7925, 7325, 6925)
        - ALSO CONSIDERING TITAN IIG AND TAURUS OPTIONS
    - BIOSHIELD INCLUDED ONLY IF REQUIRED
- CRUISE PHASE (TRANSIT FROM EARTH TO MARS)
    - PROBABLY SUN-POINTED, SPIN-STABILIZED SPACECRAFT
        - EARTH-POINT A POSSIBLE ALTERNATIVE
        - 3-AXIS ONLY IF OVERALL COST WOULD BE LOWER
- ENTRY PHASE (POSSIBLE JETTISON OF SOME CRUISE HARDWARE; THEN, HIGH-VELOCITY, HIGH-HEAT-LOAD ENTRY)
    - PROBABLY A SPINNING, NON-LIFTING AEROSHELL (HEAT SHIELD AND BACK COVER)
- EARLY DESCENT PHASE (PROBABLE JETTISON OF HEAT SHIELD; THEN, LOW-HEAT-LOAD, LOW-TERMINAL-VELOCITY DESCENT)
    - PROBABLY A SINGLE, ROUND PARACHUTE
        - 3-PARACHUTE OPTION A POSSIBLE ALTERNATIVE
    - CONSIDERING DEPLOYMENT METHODS

MESUR PATHFINDER FLIGHT SYSTEM STATUS
TERMINAL DESCENT AND LANDING
CANDIDATES / OPTIONS FOR PRELIMINARY DESIGN

- TERMINAL DESCENT PHASE (JETTISON / REMOVAL OF PARACHUTE AND, POSSIBLY, BACK COVER. FINAL DECELERATION, IF ANY, BEFORE MARS CONTACT)
  - CONSIDERING OPTIONS WITH ZERO TO NEAR-TOTAL VERTICAL DECELERATION AND ZERO TO NEAR-TOTAL HORIZONTAL DECELERATION. EXAMPLES INCLUDE:
    - NO HARDWARE FOR FURTHER DECELERATION
    - FIXED THRUSTERS OR DEPLOYED SRMs FOR VERTICAL DECELERATION
      - WITH ALTITUDE SENSING FOR IGNITION
    - FIXED, HYDRAZINE THRUSTERS FOR VERTICAL+HORIZONTAL DECELERATION
      - WITH HORIZONTAL VELOCITY SENSING AND CONTROL
      - WITH VERTICAL VELOCITY SENSING AND CONTROL
- LANDING PHASE (FROM SURFACE CONTACT TO FINAL, STABLE ORIENTATION)
  - CONSIDERING A WIDE RANGE OF IMPACT CUSHIONING METHODS. EXAMPLES ARE:
    - DEPLOYED FEET/LEGS WITH CRUSHABLE MATERIAL IN LEGS
    - FIXED, CRUSHABLE BOTTOM LAYER
    - DEPLOYED "SNOW SHOE" CRUSHABLE STRUCTURE
    - ENCOMPASSING, CRUSHABLE OUTSIDE LAYER
    - DEPLOYED, ENCOMPASSING, SPHERICAL AIR BAG
    - DEPLOYED, STACKED TOROIDAL AIR BAGS
    - DEPLOYED, SPHERICAL AIR BAG TETRAHEDRON
  - CONSIDERING OPTIONS THAT DO AND DO NOT HAVE SELF-UPRIGHTING CAPABILITY
    - MULTIPLE, DEPLOYED "PETALS" CAN PROVIDE UPRIGHTING

MESUR PATHFINDER FLIGHT SYSTEM STATUS
TERMINAL DESCENT AND LANDING
CANDIDATES / OPTIONS FOR PRELIMINARY DESIGN (CONTINUED)

- EXAMPLES OF MODERATE-G TERMINAL DESCENT AND LANDING COMBINATIONS
  - WITH NO DECELERATION IN TERMINAL DESCENT
    - LAND ON DEPLOYED, STACKED TOROIDAL AIR BAGS
      - GRAVITY UPRIGHTS INTERNAL STRUCTURE
      - THEN DEFLATE AIR BAGS
    - LAND ON DEPLOYED AIR BAG TETRAHEDRON
      - DEFLATE AIR BAGS
      - UPRIGHT BY DEPLOYING 3 SIDES OF INTERNAL TETRAHEDRON
  - WITH IMPULSIVE, PARTIAL VERTICAL DECELERATION IN TERMINAL DESCENT
    - LAND ON ≥4 DEPLOYED FEET/LEGS WITH CRUSHABLE MATERIAL IN LEGS
      - (NOT VIABLE IF MAXIMUM HORIZONTAL VELOCITIES ARE HIGH)
  - WITH HORIZONTAL AND VERTICAL DECELERATION IN TERMINAL DESCENT
    - LAND ON 3 DEPLOYED FEET/LEGS WITH CRUSHABLE MATERIAL IN LEGS
    - LAND ON THIN, CRUSHABLE BOTTOM LAYER

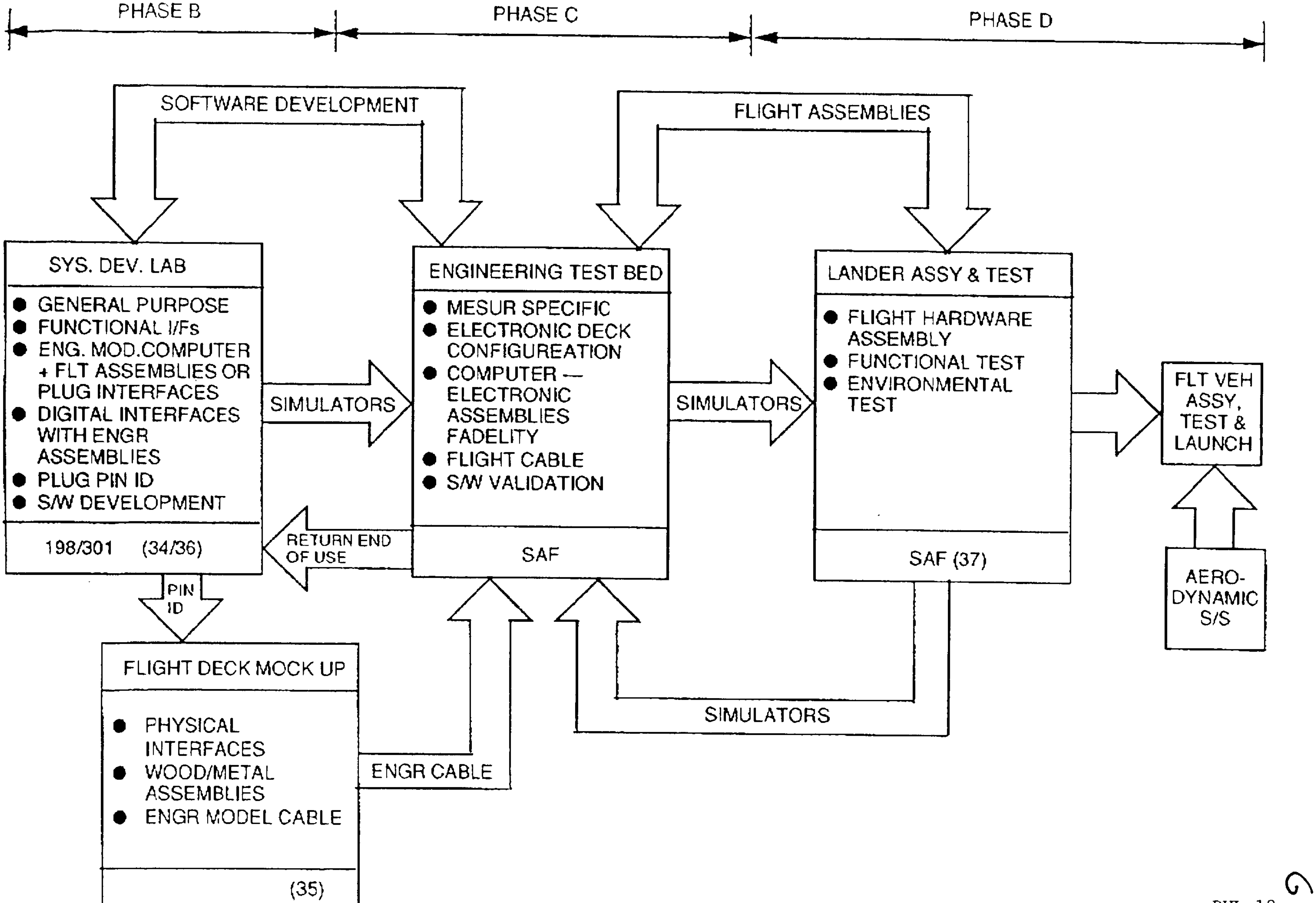
MESUR PATHFINDER FLIGHT SYSTEM STATUS
NEAR-TERM SCHEDULE

- CONTINUING TECHNICAL MEETINGS WITH OTHER LABS, INDUSTRY, ETC.
- CONTINUING DEVELOPMENT OF CONCEPTUAL DESIGN AND IMPLEMENTATION PLANS
- COST / CAPABILITY VERIFICATION STARTS IN JUNE
- CONCEPTUAL DESIGN MODIFICATIONS AS NECESSARY IN EARLY JULY
- INTERNAL REVIEW ON 24 JULY
- PRELIMINARY CONCEPTUAL DESIGN PRESENTATION TO NASA ON 29 JULY
- FURTHER DESIGN AND COST / CAPABILITY VERIFICATION IN AUGUST-OCTOBER
- INTERNAL REVIEW AND DETAILED DESIGN PRESENTATION TO NASA IN LATE OCTOBER

MESUR PATHFINDER FLIGHT SYSTEM STATUS

BACKUP CHARTS

FIGURE 2: MESUR PATHFINDER DEVELOPMENT FLOW CONCEPT



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6/17/92

MESUR PATHFINDER COSTING SCHEDULE

ACTIVITY/MIILESTONE	ORG.	APR	MAY	JUNE	JULY	AUG	SEP	OCT
FLIGHT SYSTEM PLAN (TECH. & PROG.)	DC			P 19	U 16		14	
COST ESTIMATE APPROACH	DC,DL,WR		P U			U 7		
DEVELOP WBS	DC,B,WR,DL		P U			U 28		
DEVELOP PROJECT SCHEDULE	DL			P 12	U 19			
MODEL ESTIMATES								
RUHLAND	WR				P 2, U 21			U 9
RUHLAND COG. E TALKS	WR,DC		11	8, 22, 26				
SAIC	STANCATI			I 19	P 2, U 21			U 9
DIVISION SUPPORTED PRELIMINARY COST PLAN								
S/S COST ALLOCATIONS	DC, WR	24		19				
COST GUIDELINES TO PROJECT	DL			12				
"ONE-ON-ONE" COG-E &								
PROJECT COST DISCUSSIONS	DC,DL			22 26				
COG-E COST PLAN	COG-E's			22	2			
(SECTION/DIV REVIEW NOT REQUIRED)								
MOD. TECH BASELINE AS REQ'D	DC				6, 16			
PREPARE PRELIMINARY EST.	DL				2, 23			
JPL REVIEW	DL, ET AL				24			
NASA REVIEW	DL, ET AL				29			
DIVISION "ONE-ON-ONE" MTG's	DC,DL			8	2			
DIVISION SUPPORTED UPDATED COST ESTIMATE								
UPDATED COST ALLOCATIONS	DC,WR					31		
UPDATED COST GUIDELINES	DL						11	
COG-E COST PLAN UPDATE	COG-E's						14 25	
- SIM's (NON-SRM)								
ONE-ON-ONE COG-E REVIEW	DC,DL						28	2
PREPARE UPDATE	DL						21	9
JPL REVIEW	DL, ET AL							13,14
NASA REVIEW	DL, ET AL							20,21,22
DIVISION "ONE-ON-"ONE MTG.	DC,DL						28	2

B: BARTERA
DC: DAVID COLLINS
DL: DAVID LEHMAN
WR: WILLIAM RUHLAND

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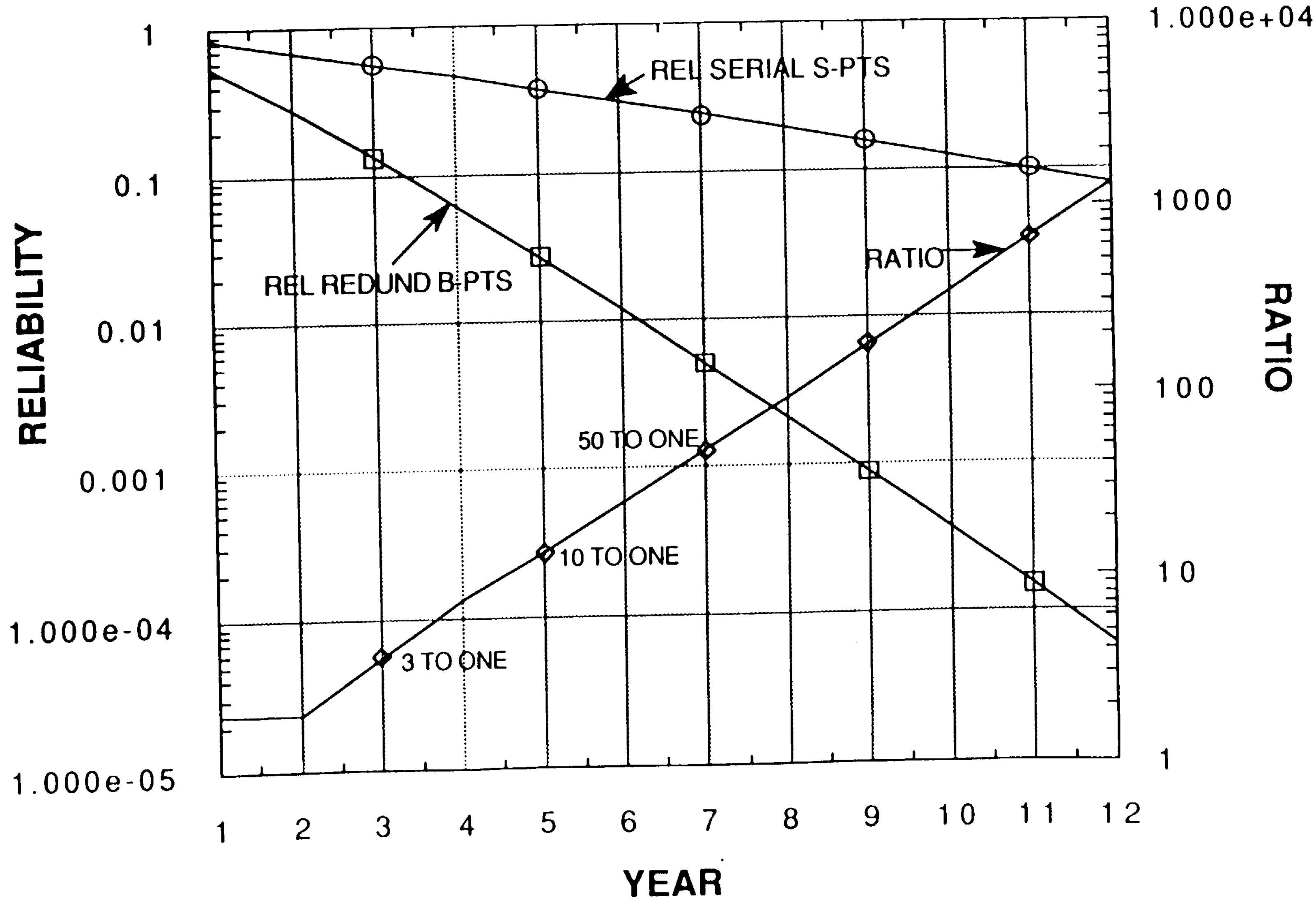
6/17/92

FIGURE 3

COMPARISON OF SERIAL SYSTEM W/S-PARTS WITH SELECTIVE REDUNDANT SYSTEM W/B-PTS



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6/17/92

MARS SWG MEETING

MARS SCIENCE MICROROVER DEMONSTRATION

MICROROVER for MESUR PATHFINDER

SCIENCE TEAMS & INSTRUMENTS for MESUR

AO SCHEDULE for the MESUR MISSIONS

Arthur L. Lane

17 JUNE 1992

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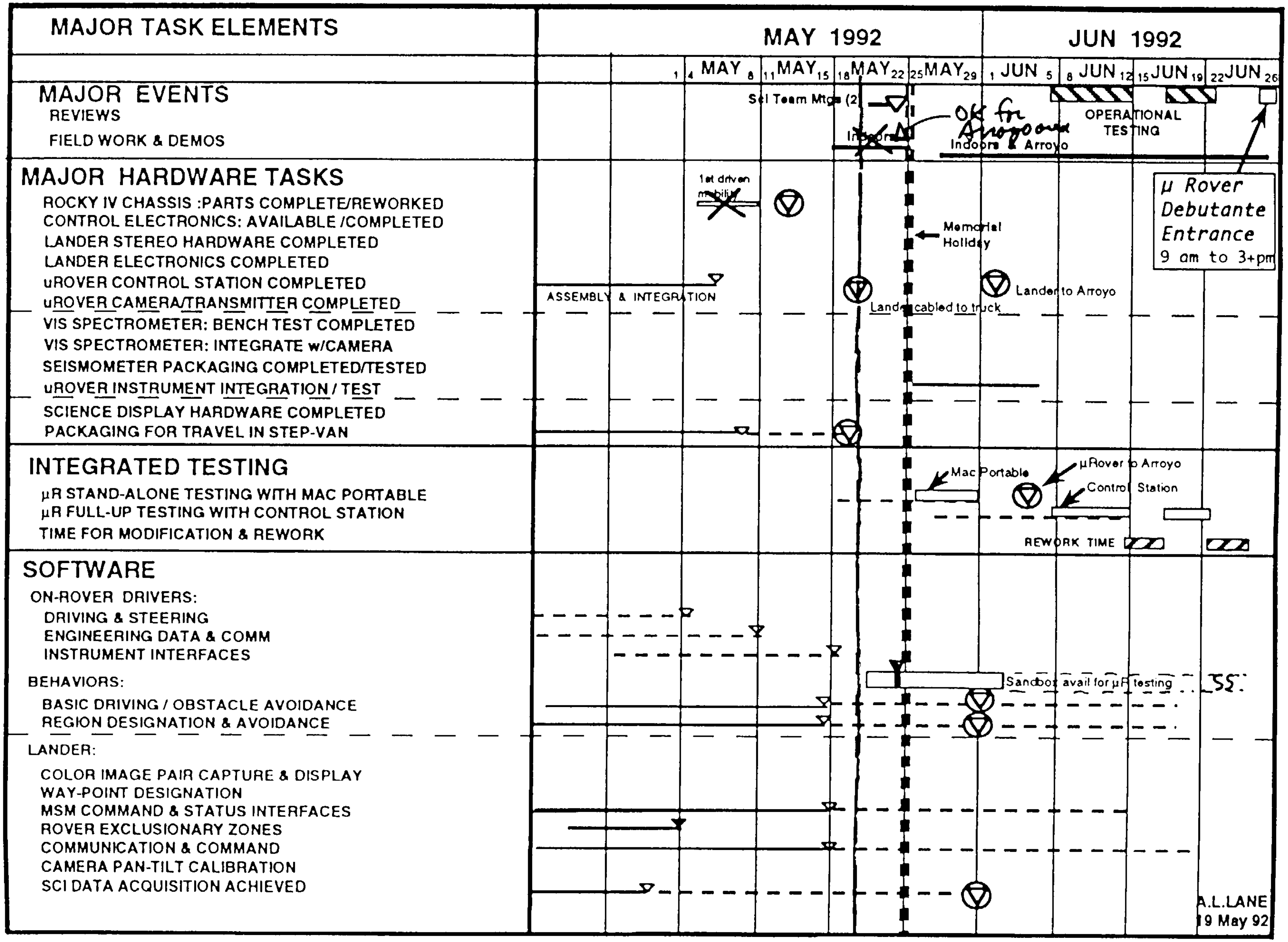
MARS SCIENCE MICROROVER DEMONSTRATION

LEVEL 1 TASK SCHEDULE



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NOTES:

MSMD activities extended from 15 June to 26 June to support the JPL 25th anniversary Surveyor landing celebration.

(▽ in circle) = Best estimate of task completion

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MARS SCIENCE MICROROVER DEMONSTRATION PROJECT

STATUS

- THE MICROROVER WILL PROBABLY MAKE ITS SCHEDULED DEMONSTRATION ON 26 JUNE

- ABOUT 80% OF THE FUNCTIONALITY PLANNED IN NOVEMBER 1991 WILL BE AVAILABLE

- CODE SL, CODE R & JPL INTERNAL FUNDING WILL CONTINUE THE ACTIVITY AS A TEST-BED FOR AT LEAST ANOTHER 5 MONTHS

- THE PRODUCT IS A 7.5 - 8 Kg ROVER EQUIPPED TO TEST SCIENCE INTERACTIONS IN THE EARTH-ANALOG OF A MARTIAN ROCK & SAND ENVIRONMENT

- AT THE TIME OF THE DEMONSTRATION THE PROJECT WILL HAVE USED 2+ MONTHS OF PLANNING, 5 MONTHS OF FABRICATION AND 3 WEEKS OF DEBUG & TEST.

A. L. Lane
16 Jun 92

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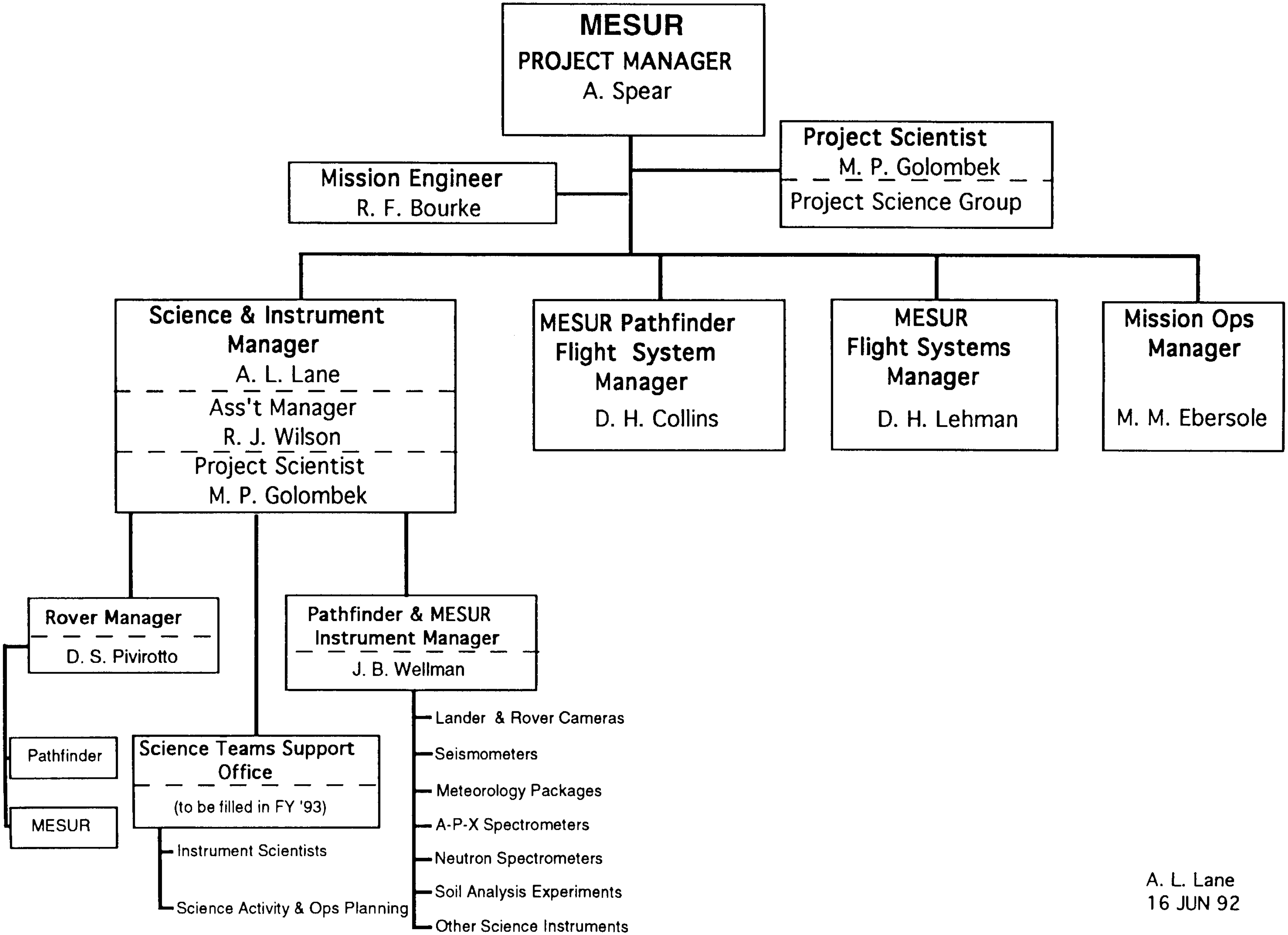

A. L. Lane
16 JUN 92

MESUR PATHFINDER MICROROVER PLAN

- INTRODUCTION
  - ROCKY IV UNDER DEVELOPMENT BY SOLAR SYSTEM EXPLORATION DIVISION AND THE OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY WILL FORM THE DEVELOPMENT BASE FOR THE PATHFINDER MICROROVER
  - THE CHALLENGE FOR PATHFINDER, IS TO DEMONSTRATE SURVIVABILITY OF LANDING, SUCCESSFULLY DEPLOYMENT AND SURFACE OPERATIONS IN THE MARS COLD AND DUSTY ENVIRONMENT, WHILE TRAVELING MORE THAN 50M AWAY FROM THE LANDER, 270 DEGREES AROUND THE LANDER, FOR A PERIOD OF AT LEAST 30 DAYS
- COMMITTMENT
  - JPL IS COMMITTED TO THE SUCCESSFUL ACCOMPLISHMENT OF THIS CHALLENGING AND EXCITING MICROROVER TASK FOR NASA'S FIRST DISCOVERY MISSION AND IS COMMITTED TO SUPPORT THE MESUR PROJECT IN ITS QUICK REACTION, DESIGN TO COST APPROACH

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MESUR PATHFINDER MICROROVER PLAN

ASSUMPTIONS AND CONSTRAINTS

- ROVER CAN BE UP TO 10 KG TOTAL MASS -- TARGET IS 7 KG
- ROVER OPERATIONS WILL OCCUR BETWEEN 10 AM - 3 PM EACH SOL
- ROVER WILL OPERATE ON MARTIAN SURFACE FOR MORE THAN 30 DAYS
- WILL PROVIDE ENGINEERING AND IMAGING DATA NECESSARY FOR CODE R EXPERIMENTS
- POWER, COMMAND, & COMMUNICATIONS VIA TETHER TO LANDER
  - 2 - 3 WATT AVERAGE LOAD
  - BATTERY ON ROVER TO HANDLE UP TO 30 WATT PEAK POWER
- ROVER CAPABILITY TO TRAVEL MORE THAN 50M FROM THE LANDER AND TO CIRCLE THE LANDER UP TO 270 DEGREE WITH TOTAL TETHER LENGTH OF 150 TO 300M
- USE LANDER COMPUTER FOR MICROROVER CONTROL, DATA PROCESSING, DATA COMPRESSION AND STORAGE
  - BEHAVIORAL CONTROL ALGORITHMS AND SENSOR PROCESSING AT LEAST AS GOOD AS ROCKY IV
  - IMAGE COMPRESSION
- USE 'RHUs' FOR THERMAL HEATING
  - USE 1/8 WATT STRIP HEATERS AT CRITICAL LOCATIONS

MESUR PATHFINDER MICROROVER PLAN

CODE R OBJECTIVES

- GATHER ENGINEERING DATA ON THE PHYSICS OF MICROROVER-MARS INTERACTIONS FOR DESIGNING FUTURE MICROROVER FOR MARS, THE MOON, AND OTHER BODIES
  - SOIL MECHANICS
  - CHEMISTRY
  - ABRASION
  - DUST
  - RADIATION
- EVALUATE THE ACCURACY OF MICROROVER PERFORMANCE PREDICTIONS EXTRAPOLATED FROM TERRESTRIAL PERFORMANCE MEASUREMENTS
- VERIFY THE EFFECTIVENESS AND ROBUSTNESS OF MICROROVER DESIGN APPROACH
- COMPARE/VERIFY THE EFFECTIVENESS OF OVERALL MICROROVER CONTROL APPROACHES
- VERIFY THE UTILITY OF MICROROVERS IN EXTRATERRESTRIAL SCIENTIFIC INVESTIGATIONS

MESUR PATHFINDER MICROROVER PLAN

CODE R EXPERIMENT SCOPE

- EVALUATE TECHNOLOGIES REQUIRED FOR MESUR NETWORK/ROVER MISSION
- EVALUATE TECHNOLOGIES FOR FUTURE MARS SAMPLE RETURN MISSION
- EVALUATE TECHNOLOGIES FOR ROVER MISSIONS TO THE SURFACES OF OTHER CELESTIAL BODIES

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MESUR PATHFINDER MICROROVER PLAN

CODE S MISSION OBJECTIVES

- DEMONSTRATE SAFE LANDING, DEPLOYMENT, AND SURFACE OPERATIONS
- DEMONSTRATE THAT THE MICROROVER CONTRIBUTES TO SCIENCE DATA ACQUISITION AT A SIGNIFICANT DISTANCE FROM THE LANDER
  - CANDIDATE EXPERIMENTS: DEPLOY SEISMOMETERS, PLACE ALPHA/PROTON/X-RAY SPECTROMETERS AGAINST ROCKS, DIG AND CHIP, CLOSE-UP EXAMINATIONS OF ROCKS, LOOK FOR WATER AT MANY LOCATIONS

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ISSUES FOR CODE SL WITH RESPECT TO µRover FOR MESUR

SL wants to perform and achieve science return from MESUR PF & NT, with the hope that the µrover can provide a meaningful scientific enhancement return, as well as providing a stimulus to the public on planetary exploration. This requires that the µrover be tested in the germane planetary environment, very early in the mission lifetime cycle, so that the later launches of the Network elements can have the benefit of potential rover-enabled science return.

Issues for MESUR-PF:

- Development of a µrover with a chassis & support function mass of ≤ 4 kg for eventual flight on the later launches '99 - '03. PF '96 launch should be able to handle a Rocky IV mass of about 8 kg.

- Demonstration of the µrover to handle mobility issues within the real Martian environment -- namely, navigation in a rock-strewn field similar to that observed at the Viking I and 2 landing sites. Embedded within this issue are many facets of physio-mechanical characteriztion of the Martian soil and rocks.

- Development and demonstration of the command structure, necessary driving behaviors, and safing protections which enable the µrover to be a general purpose platform for performing or enabling scientific studies.

- Demonstate that the µrover can do useful work; such as deploy a seismometer away from the lander to diminish induced structural noises, chip 20 - 50 µm off a rock's surface to enable an elemental/mineralogical assessment of the interior of the rock, explore and image regions not accessible to the lander cameras (looking closely at the base of rocks for understanding wind-blown soil distributions, examining the landing pads of the lander for structural damage, etc), push small rocks to examine soil which has been protected for possibly 1000 to 10,000,000 years from UV flux, ...

- Provide an environment in which the public and scientific community actively support the Network mission and eagerly await the next series of activities related to Mars exploration.

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SURFACE OPERATIONS WITH A PATHFINDER μROVER

- Successful extraction of the μrover from the lander structure onto the Martian surface

- Observation of the μrover by the lander camera(s) showing movement from one place to another within the near-field of the lander

- If an engineering unit seismometer is carried as part of the payload, the μrover will deploy it somewhere off the lander at a range of 2 to 5 meters from the lander structure. (Science has requested at least one lander scale length separation.)

- If an a-p-x spectrometer is carried on the μrover, approach a rock/spatial structure of interest as determined from the lander imaging. Maneuver the μrover to provide a detailed image of the object/zone of interest. Place the a-p-x spectrometer in the proper geometry to integrate and acquire elemental composition data. If possible, re-image from either the rover, lander or both to verify location of acquired data.

- If a rock "chipping" tool is carried on the μrover, place tool to remove some 10 - 40 μm of surface material, re-image with rover camera to observe the effect of the chipping effort, consider re-placement of a-p-x spectrometer to see if sub-surface has a different elemental composition than the exposed outer surface.

- If a simple neutron spectrometer is carried on the μrover, plan and execute a series of traverses under combined way-point and behavioral control to examine the sub-surface hydrogen distribution. Because the μrover operational daily window is limited to about 5-6 hours, this activity will require a number of sols to complete. Intersperse rock studies with this activity.

SURFACE OPERATIONS WITH A PATHFINDER μROVER (con't)

- If μrover is equipped with a scrapper blade, find a space in which a trench can be plowed. After 5-10 cm of excavation, use close-up camera to decide if an a-p-x spectrometer measurement should be performed. Continue excavation effort, with goal of trying to clear 20 - 40 cm of soil. If embedded rock is encountered, perform optical and a-p-x spectrometer analyses.

- Continue to explore the local area around the lander and if μrover appears to have strong likelihood of continued operability, plan and execute longer range excursions to and beyond local horizon limit.

- Be creative -- there are many activities one can design and accomplish over a month to a few months, given the systems survive and operate.

MARS SWG MEETING 17 JUNE 1992

SCIENCE INSTRUMENTS

- **MESUR NETWORK** WILL CARRY BOTH "MUST FLY" AND PI-TYPE INSTRUMENTS. MUST-FLYs INCLUDES SEISMOMETERS, METEOROLOGY PACKAGES, ATMOSPHERIC STRUCTURE PKG, & LANDER CAMERA SYSTEM. PI-TYPEs INCLUDE MINERALOGY, ELEMENTAL ANALYSIS, EGA/TGA, NEUTRON SPECTROMETERS, SPECIALIZE TASK INSTRUMENTS,.... MICROROVERS ARE SPECIAL.

- **MESUR PATHFINDER** IS SEVERELY CONSTRAINED IN CAPABILITIES.

- WILL FLY ATMOSPHERIC STRUCTURE (T,P,a), LANDER CAMERA(S).

- WILL FLY A MICROROVER (CODE R EFFORT)

- POSSIBLE OTHERS: A-P-X SPECTROMETER, MICROSEISMOMETER, SIMPLE NEUTRON SPECTROMETER, SOIL ANALYSIS EXPERIMENT. OTHERS UNDER CONSIDERATION. RESOURCES VERY LIMITED.

MARS SWG MEETING 17 JUNE 1992

SCIENCE TEAMS FOR PATHFINDER

- CODE SL ***MAY*** SELECT/APPOINT INTERIM PROJECT SCIENCE GROUP LED BY PROJECT SCIENTIST

- THESE MEMBERS SUPPORT THE INSTRUMENT EFFORT UNTIL JUST BEFORE AN AO IS RELEASED

- AO FOR INSTRUMENTS & TEAM LEADERS/MEMBERS OUT NOV '92 AND SELECTED BY MARCH '93.

- AO FOR PARTICIPATING SCIENTISTS FOR TEAMS OUT 10 MONTHS BEFORE LAUNCH. ON BOARD ABOUT 4 MONTHS BEFORE LAUNCH

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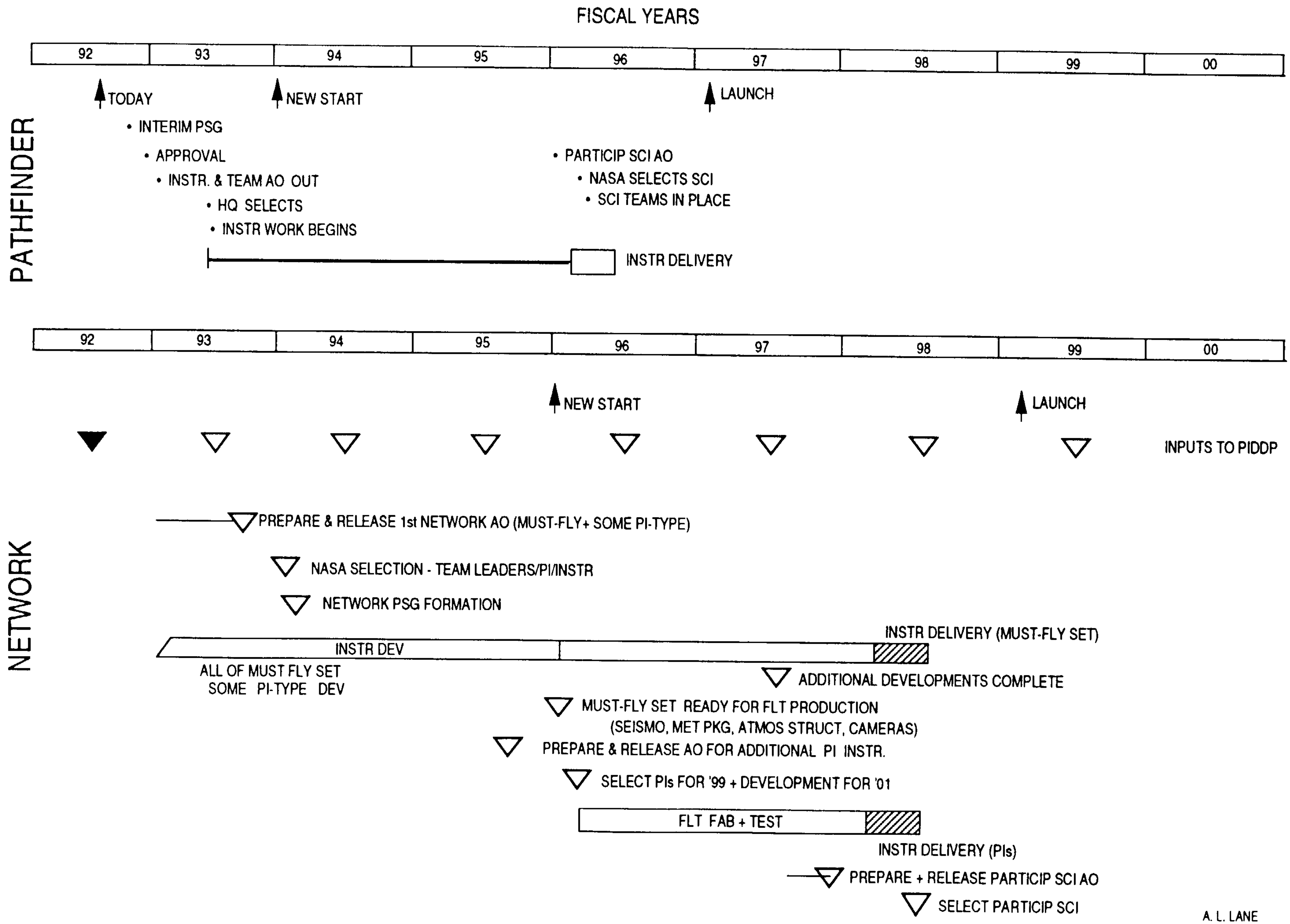
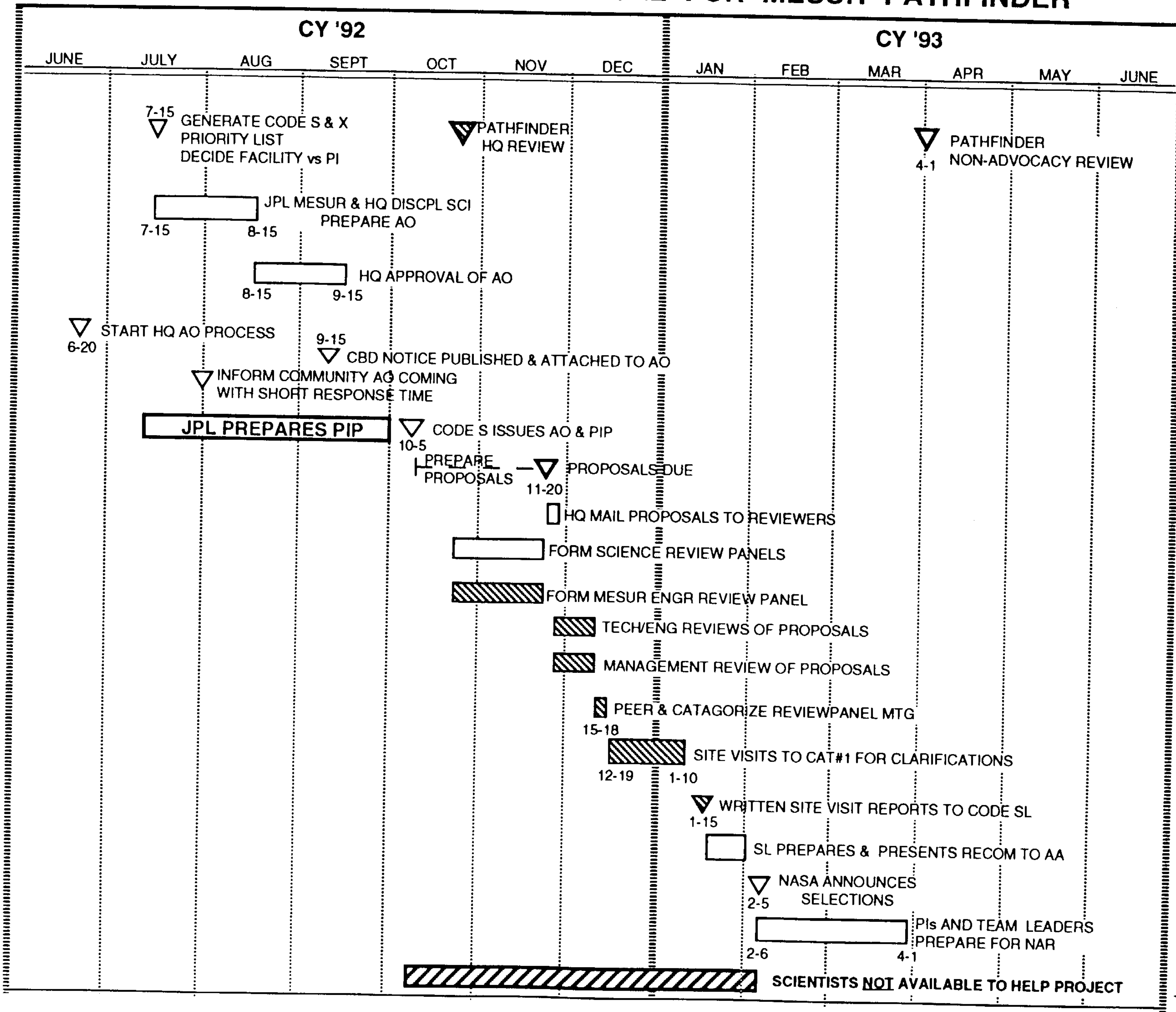
MESUR SCIENCE AND INSTRUMENT SCHEDULE



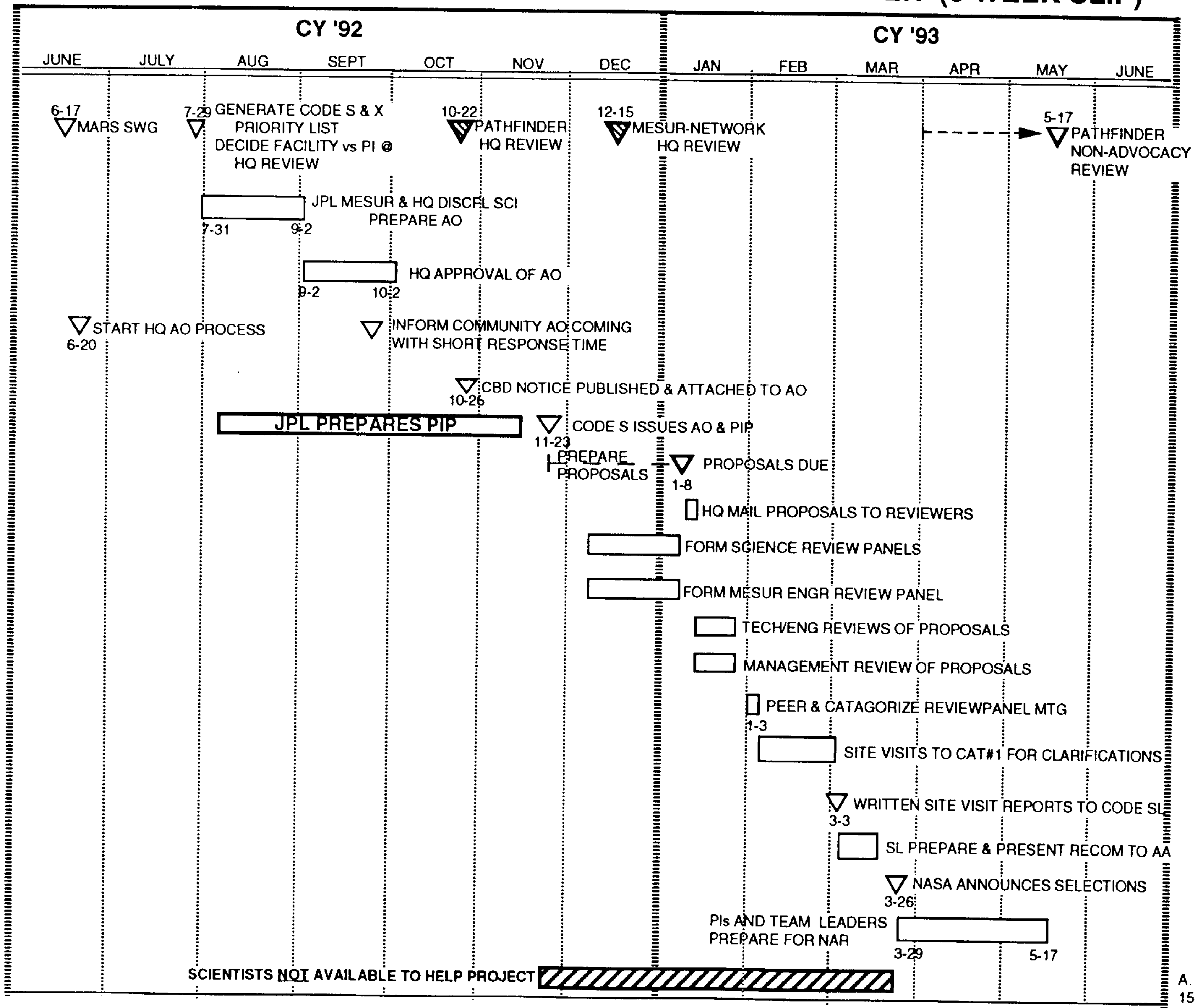
A. L. LANE
15 JUN 92

DEVELOPING AN AO SCHEDULE FOR MESUR PATHFINDER



A. L. LANE
13 JUN 92

DEVELOPING AN AO SCHEDULE FOR MESUR PATHFINDER (6 WEEK SLIP)



A. L. LANE
15 JUN 92

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JPL

MESUR/MARSNET Coordination
Presentation to MarsSWG
17 June 92
Roger Bourke

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JPL

Status of MARSNET

- Phase A contractor on board since January 1992
  - Phase A1 report given 16 April
- Phase A culminates in selection for phase B by Science Program Committee in May 1993
- Quarterly Science Team meetings
  - Strawman objectives and payload adopted

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JPL

Strong communications between MARSNET and MESUR

- Cross attendance at MESUR SDT and MARSNET Science Team meetings
- MARSNET engineering managers attended June MESUR workshops on:
  - Communications orbiter vs direct link
  - Launch to landing
  - Lessons learned from planetary entry & landing missions

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JPL

Interface understandings have been written for:

- Spacecraft design (attached)
- Communications

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JPL

Outstanding issues

- Science complementarity
  - Despite very strong attempts by the US, no significant science complementarity has been achieved. Instead, the MARSNET payload and mission is nearly identical to that of MESUR
  - Many in the US have seen this as a potential barrier to selection for phase B, but ESA management does not seem to share this concern
- Cruise support
  - MARSNET landers are not as self-sufficient as MESUR and need some sort of probe delivery system to the vicinity of Mars.
  - NASA has volunteered to furnish a "probe carrier", either multi- or single for each of the landers

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JPL

Outstanding issues (cont.)

    - The current Pathfinder concept does not use an identical "probe carrier" hence it appears this development is exclusively for MARSNET and not for MESUR

- Network operations
  - MARSNET landers are not expected to last more than one Martian year
  - To contribute to full network science, this implies that MARSNET launches should be deferred to 2003
    - ESA seems to be comfortable with this schedule
  - Launch congestion in 2003 may require some alternative strategies

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JPL

How can MESUR and MARSNET become more mutually reinforcing?

- MARSNET might be used as a risk reduction element in a network emplacement strategy. The three MARSNET landers would, combined with the 16 MESUR landers, emplace a network of at least 16 elements

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MESUR LAUNCH TO LANDING WORKSHOP JPL 04/06/92

MESUR - MARSNET
ASSUMPTION REGARDING SPACECRAFT DESIGN

- MESUR PATHFINDER, MESUR NETWORK, AND MARSNET USE DIRECT ENTRY
  - THERE IS NO ORBITING PHASE AT MARS
  - DELTA V REQUIREMENTS ARE TOO LARGE

- EACH MESUR NETWORK SPACECRAFT IS INDEPENDENT AFTER L/V SEPARATION
  - THERE IS NO MULTIPLE LANDER CARRIER
  - TARGETING OPTIONS WOULD BE TOO SEVERELY CONSTRAINED

- MESUR PATHFINDER AND NETWORK DESIGNS ARE INDEPENDENT FROM MARSNET
  - HOWEVER - DESIGN INFORMATION IS SHARED FOR MUTUAL BENEFIT

- A MULTIPLE OR INDIVIDUAL LANDER CARRIER IS DESIGNED FOR MARSNET
  - THERE IS NO IMPACT ON PATHFINDER FUNDING/SCHEDULE
  - MUTUALLY SATISFACTORY INTERFACE REQUIREMENTS ARE AGREED ON

- MESUR NETWORK AND MARSNET COMPLEMENT EACH OTHER
  - TOTAL SCIENCE RETURN AND/OR MISSION RELIABILITY IS ENHANCED

Assumptions agreed between Anthony J. Spear NASA/JPL and George E. N. Scoon ESA/ESTEC

05/06/92

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MESUR CRUISING TO MARS

1.0 With MARSNET

- Pathfinder must not be impacted by a cruise carrier development for MARSNET. Pathfinder will use a cruise system integrated with the lander system.

- MESUR Network Project will deliver three MARSNET flight systems to Mars on a direct descent trajectory.

  - Either using a common carrier carrying the three flight systems or a single flight system cruise carrier carrying each of the three flight systems individually.
  - Cost in the range 10-100 Mil$ will be within the 1.0 Bil$ total, 150 Mil$/yr constraints.
  - Either at the '01 or '03 launch opportunities.
  - Development of the cruise carrier(s) will be accomplished in the 3 year period before the launch of the three MARSNET flight systems.

- The MARSNET cruise carrier(s) will provide to the MARSNET flight systems:

  - Pre-launch check of each flight system.
  - Launch Configuration. Launch loads TBD.
  - Cruise Power at 28V ± 5V and 50 ± 5 watts each flight system .
  - Landing site targeting to ± 100 KM.
  - Telemetry at less than 50 bps, each flight system.
  - Command at less than 10 bps, each flight system.
  - Verification of each flight system separation from the carriers.
  - Spin up at carrier release.
  - <u>Note</u> After separation the MARSNET flight systems will not communicate until after landing.

- MESUR Network flight systems will use either the MARSNET common or single cruise carrier(s) or use the Pathfinder integrated cruise system.

Flight System = Entry, descent, landing system and landers

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Kaplan

NASA

EXPLORATION PROGRAMS OFFICE

Exploration Programs Office

Instrumentation for MESUR/Pathfinder

Mars Science Working Group

June 17, 1992

NASA

Exploration Objectives

EXPLORATION PROGRAMS OFFICE

Exploration goals for early martian precursor missions:

Determine chemical composition and reactivity of the dust and soil.

Determine local abundance of water in minerals and ice.

Understand atmospheric properties required to conduct accurate descent navigation.

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NASA

Potential Instruments

EXPLORATION PROGRAMS OFFICE

Potential **instruments for exploration include:**

- Neutron spectrometer
- Soil thermal analysis system
- Mössbauer spectrometer
- E-M sounder
- measurement of thermal behavior of aeroshell passing through martian CO_2 atmosphere
- descent imagery

AN OPTION FOR MESUR-PATHFINDER

K)
Blamont

I - A SMALL STATION DEVELOPPED BY IKI-BABAKIN FOR THE RUSSIAN MISSION MARS-94 WOULD BE BOUGHT BY CNES :

- MASS : 35 - 40 KG ONBOARD THE SPACECRAFT
  20 KG ON MARTIAN SURFACE
  8 KG FOR SCIENCE PAYLOAD

- POWER : 2 RTG, EACH OF THEM PROVIDING 0.1 WATT ELECTRICAL

- DATA : 1 MB/DAY THROUGH RELAY (MO - MBR OR RUSSIAN S/C)

- INSTRUMENTS : DESCENT CAMERA, PANORAMIC CAMERA, α - PROTON BACKSCATTER SPECTROMETER, NEUTRON DETECTOR, SISMOMETER, MAGNETOMETER.

II - CNES WOULD PROVIDE THE STATION TO NASA FOR INCLUSION AS AN INDEPENDANT PACKAGE ON THE MESUR-PATHFINDER BUS.
THE STATION WOULD BE SEPARATED 3 TO 10 DAYS BEFORE ARRIVAL TO MARS.
NASA INSTRUMENTS WOULD BE CONSIDERED FOR EVENTUAL REPLACEMENT OF ONBOARD SENSORS.
AMERICAN P-IS AND CO-IS COULD BE CHOSEN.
THE MISSION WOULD BE A JOINT NASA-CNES VENTURE WITH NO RUSSIAN PARTICIPATION IN THE MANAGEMENT : THE MISSION WOULD BE PLAYING THE ROLE OF A SUBCONTRACTOR.

K

AN OPTION FOR MARS-96

TODAY, THE ACCEPTED MISSION HAS FOR COMPONENTS:

- AN ORBITER WITH SIMPLIFIED SCIENCE
- A DESCENT MODULE WITH BALLOON AND ROVER
- SMALL STATIONS (2) ARE CONSIDERED
- THERE IS TALK ABOUT INCLUDING PENETRATORS

THERE IS ALSO A BARZUKOV EFFORT (NOT YET APPROVED) FOR A SIMULTANEOUS MISSION WHICH WOULD PLACE PENETRATORS ON MARS AND CONTINUE TOWARDS ASTEROIDS.

A POSSIBLE OPTION WOULD BE TO USE THE LAUNCHER AND PROBE HOPED FOR BY BARZUKOV TO CARRY TO MARS A MISSION IDENTICAL TO THE APPROVED MISSION. THE DESCENT MODUL WOULD BE BOUGHT BY CNES. THE ROVER WOULD BE BOUGHT BY NASA AND AN AMERICAN PAYLOAD PLACED ON BOARD.

THE SMALL STATIONS IN THE '96 MISSION COULD BE A PART OF THE PATHFINDER MESUR OR EVEN BE THE PATHFINDER MESUR MISSION

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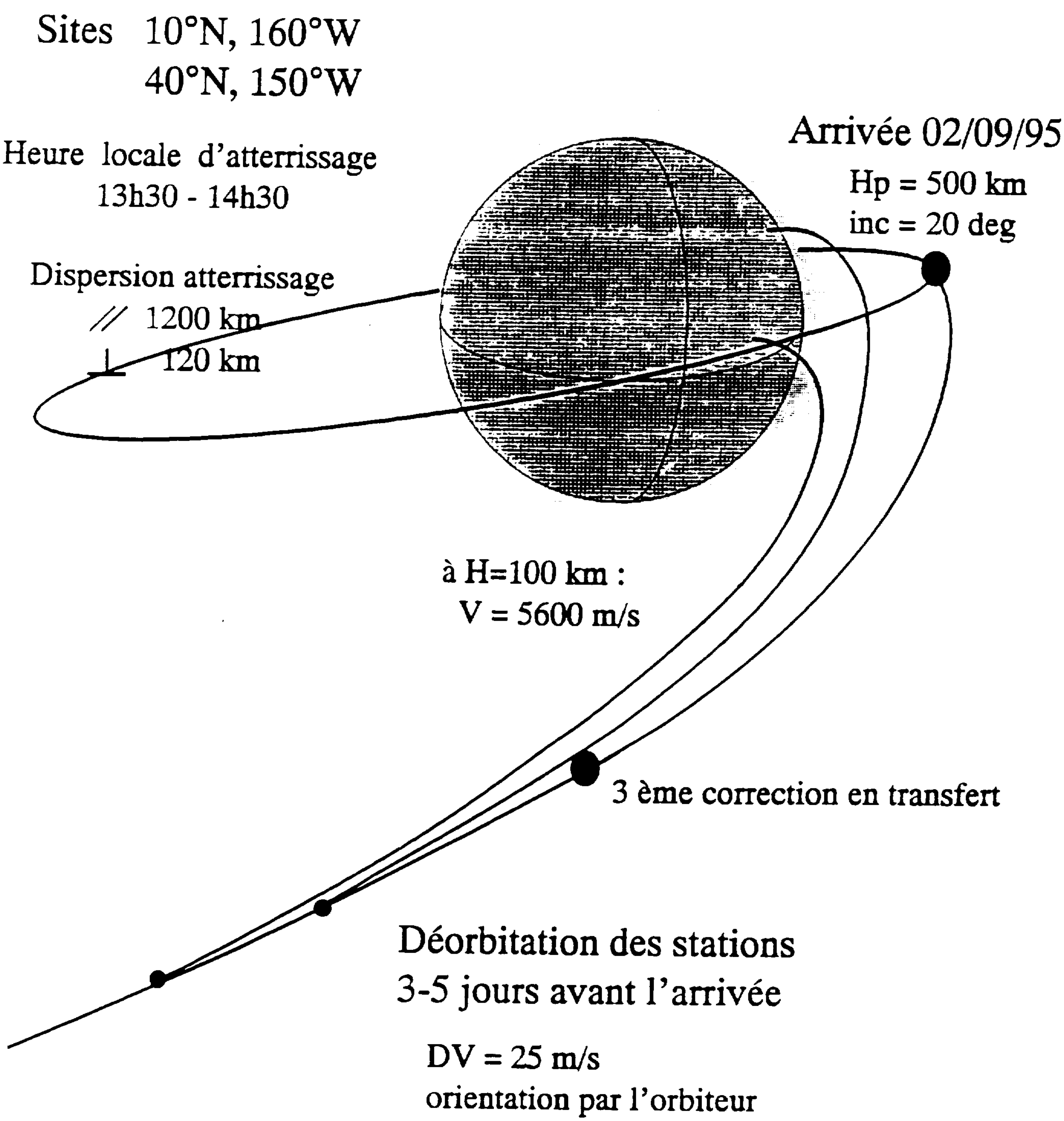
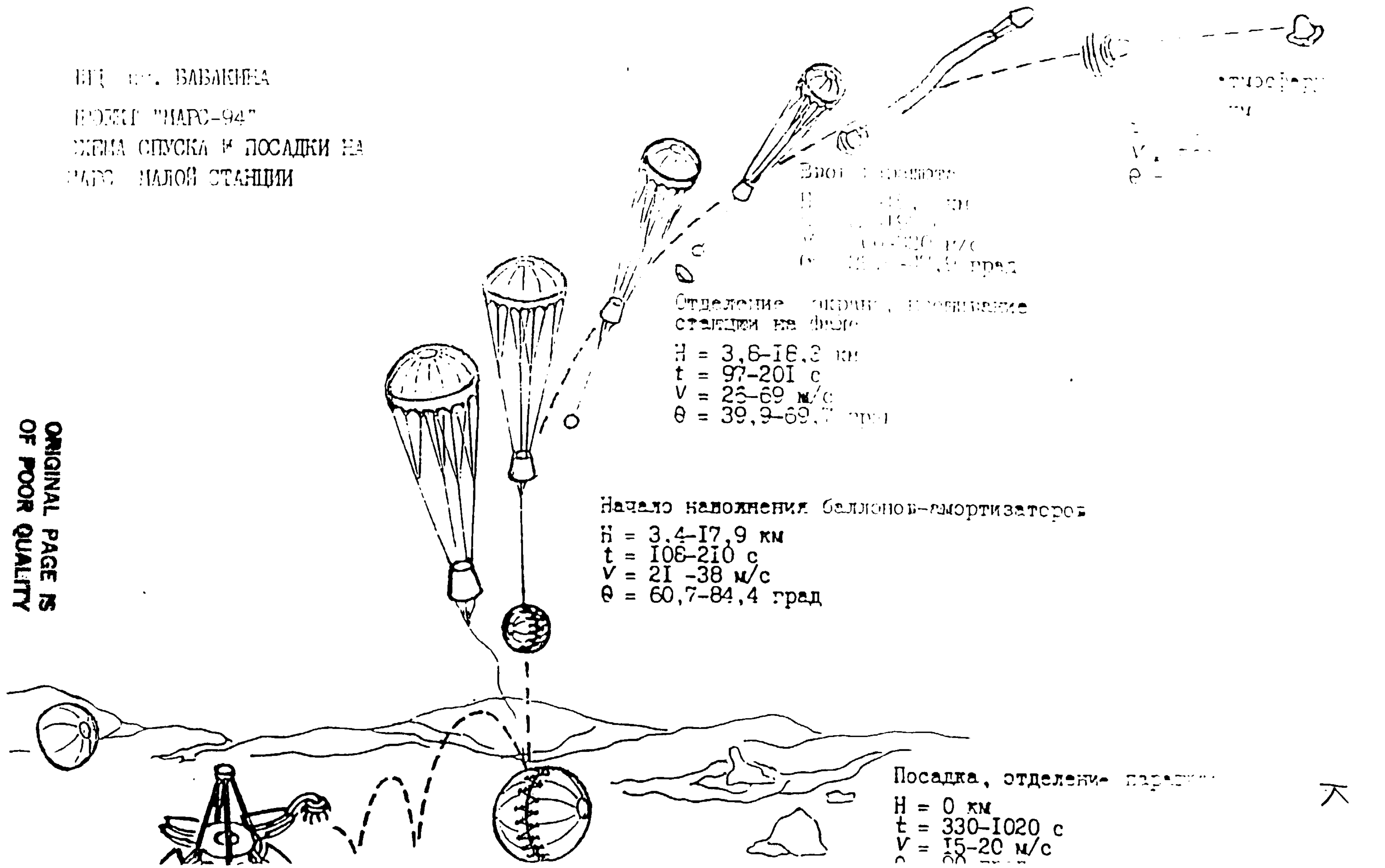
DESCAM


Sites 10°N, 160°W
40°N, 150°W
Heure locale d'atterrissage
13h30 - 14h30
Dispersion atterrissage
// 1200 km
⊥ 120 km
Arrivée 02/09/95
Hp = 500 km
inc = 20 deg
à H=100 km :
V = 5600 m/s
3 ème correction en transfert
Déorbitation des stations
3-5 jours avant l'arrivée
DV = 25 m/s
orientation par l'orbiteur

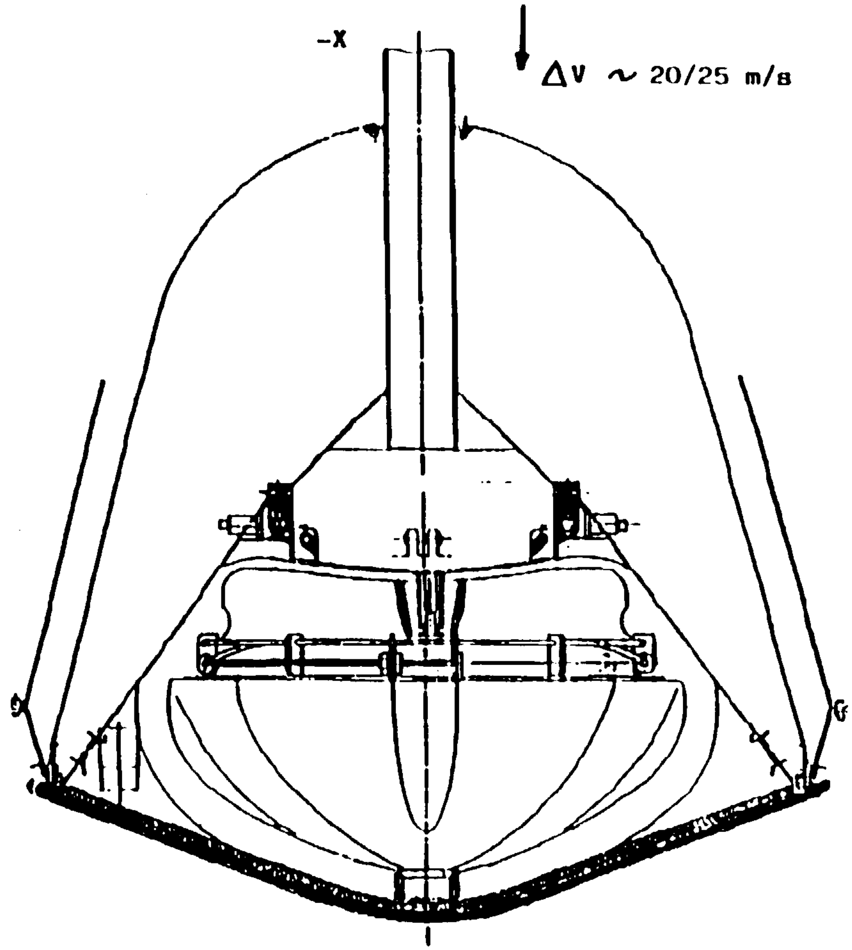
НПО им. БАБАКИНА

ПРОЕКТ "МАРС-94"
СХЕМА СПУСКА И ПОСАДКИ НА
МАРС МАЛОЙ СТАНЦИИ



THE MARS 94 SMALL STATIONS

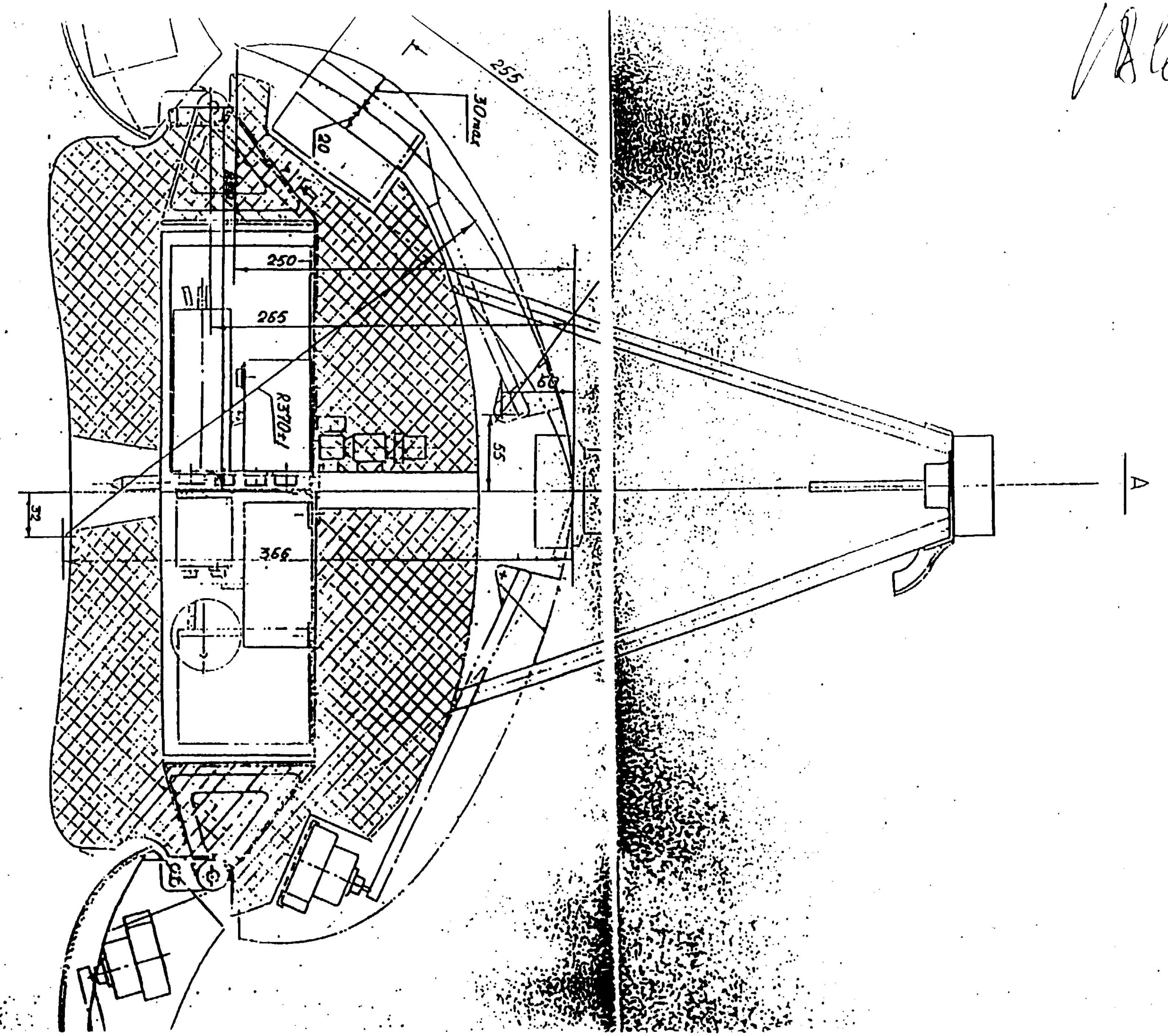
J. Blamont



THE SMALL STATION SEEN FROM

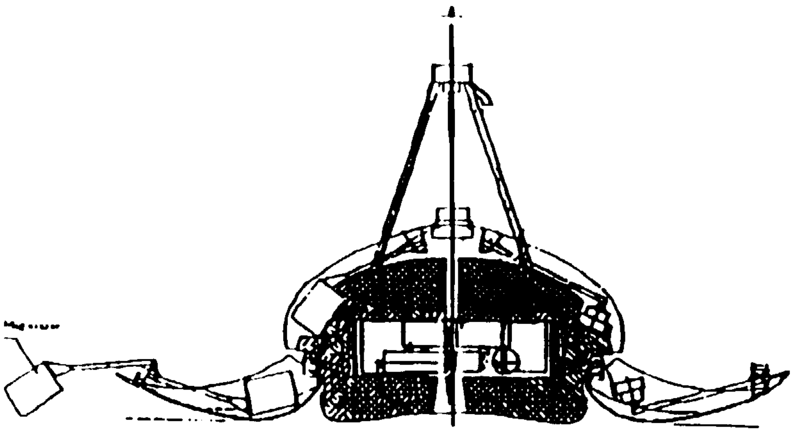
THE SIDE BEFORE LAUNCH

(MASS ON ORBITER < 30 Kg)

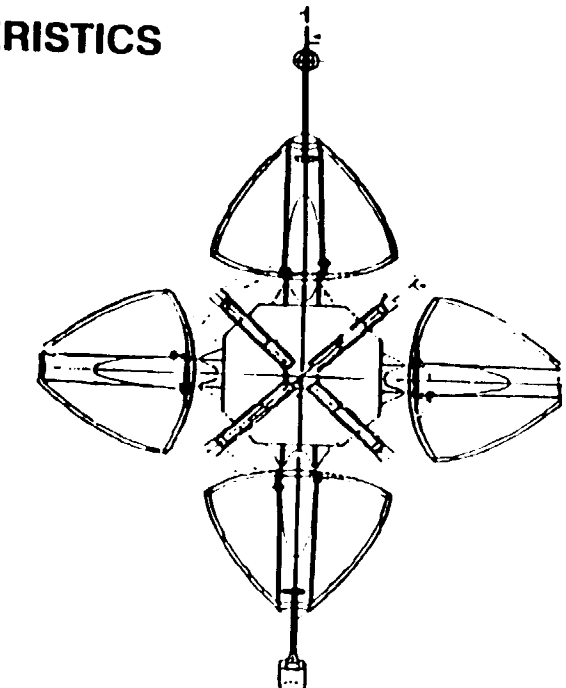

255
30 max
20
250
265
R370
60
55
32
366
A

THE MARS 94 SMALL STATIONS

MAIN CHARACTERISTICS



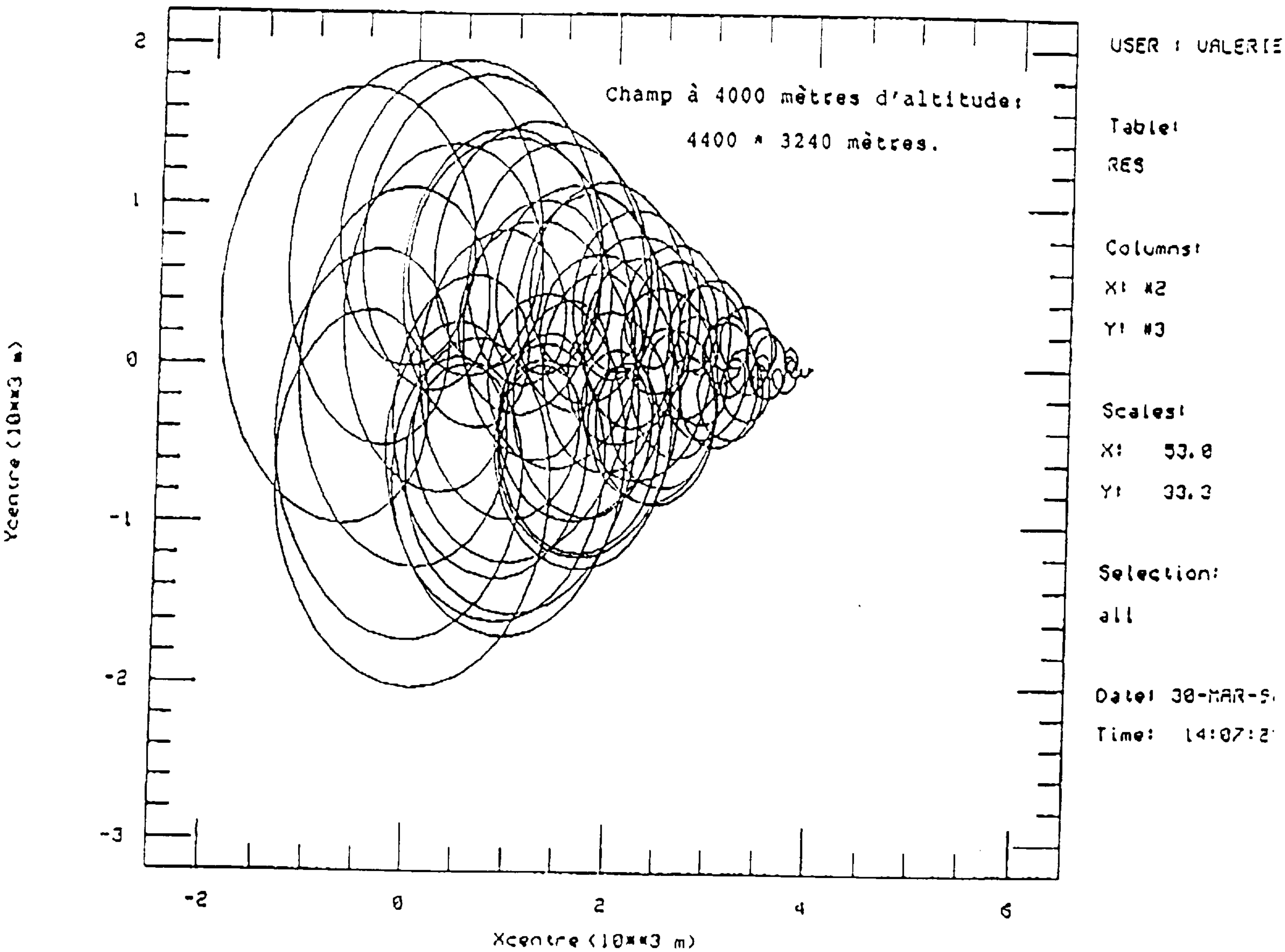
LANDED CONFIGURATION
SEEN FROM THE SIDE



LANDED CONFIGURATION
SEEN FROM ABOVE

- TOTAL PAYLOAD MASS = 10 Kg (WITH 10 % MARGIN AND INCLUDING POWER SUPPLY, RADIOSYSTEM AND CENTRAL ELECTRICAL BLOCK
- POWER SUPPLY = 2 x 100 mW RTG (15 V)
- MASS MEMORY = 30 MEGABITS
- DATA DUMPED TO MARS OBSERVER AND MARS 94 ORBITER WITH FOLLOWING DATA RATE
  8 KBITS / S (M.O.) & 2 KBITS / S (M94)

Par ailleurs, le recouvrement des champs est constamment réalisé, comme en atteste la taille du champ de la caméra 8 mm à 4000 mètres d'altitude, qui recouvre la totalité du tracé (le champ de la caméra croissant pendant la descente, cette condition sera toujours réalisée). Les traces au sol du centre et du bord du champ de la caméra grand angle sont présentés figures 2 et 3.



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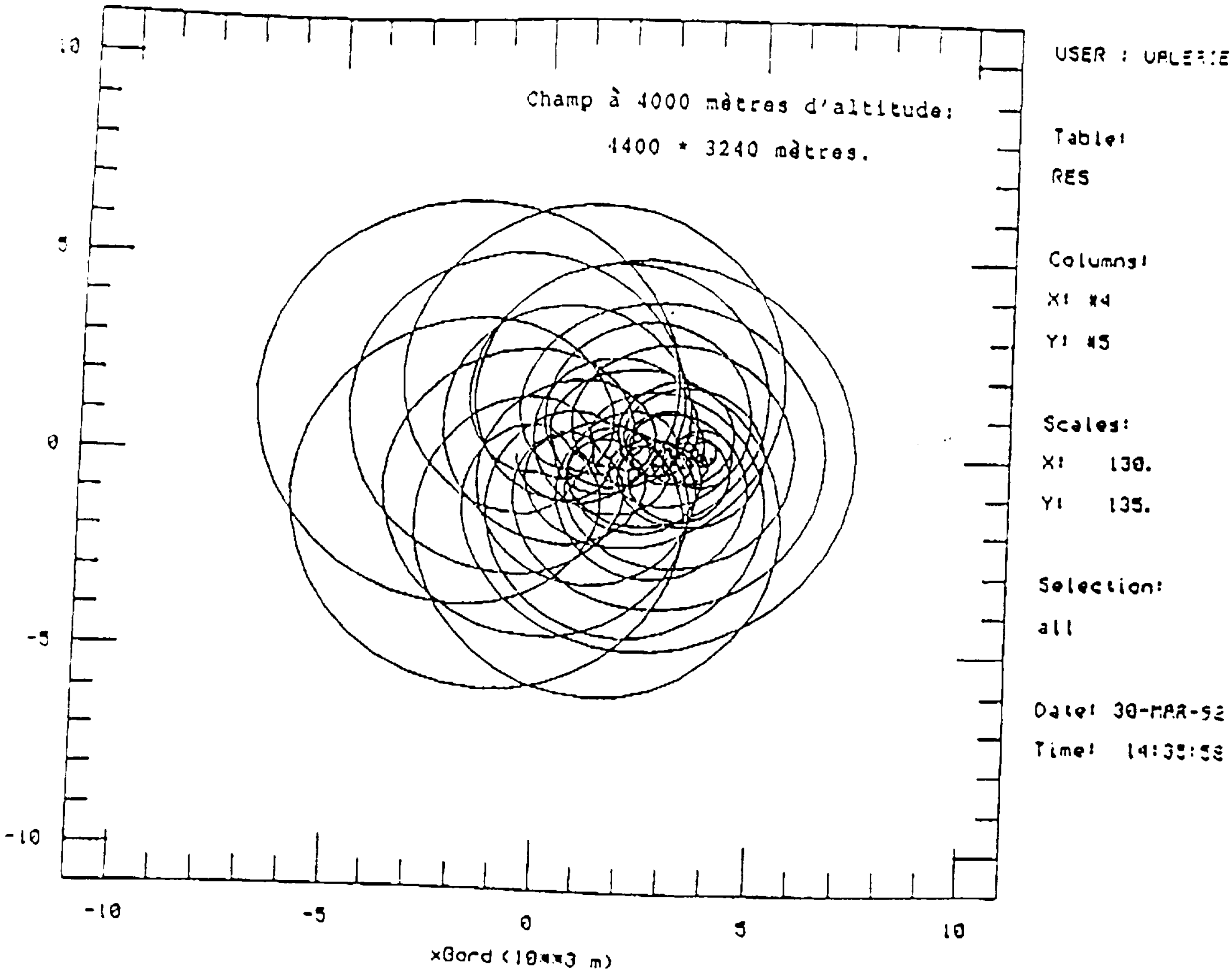
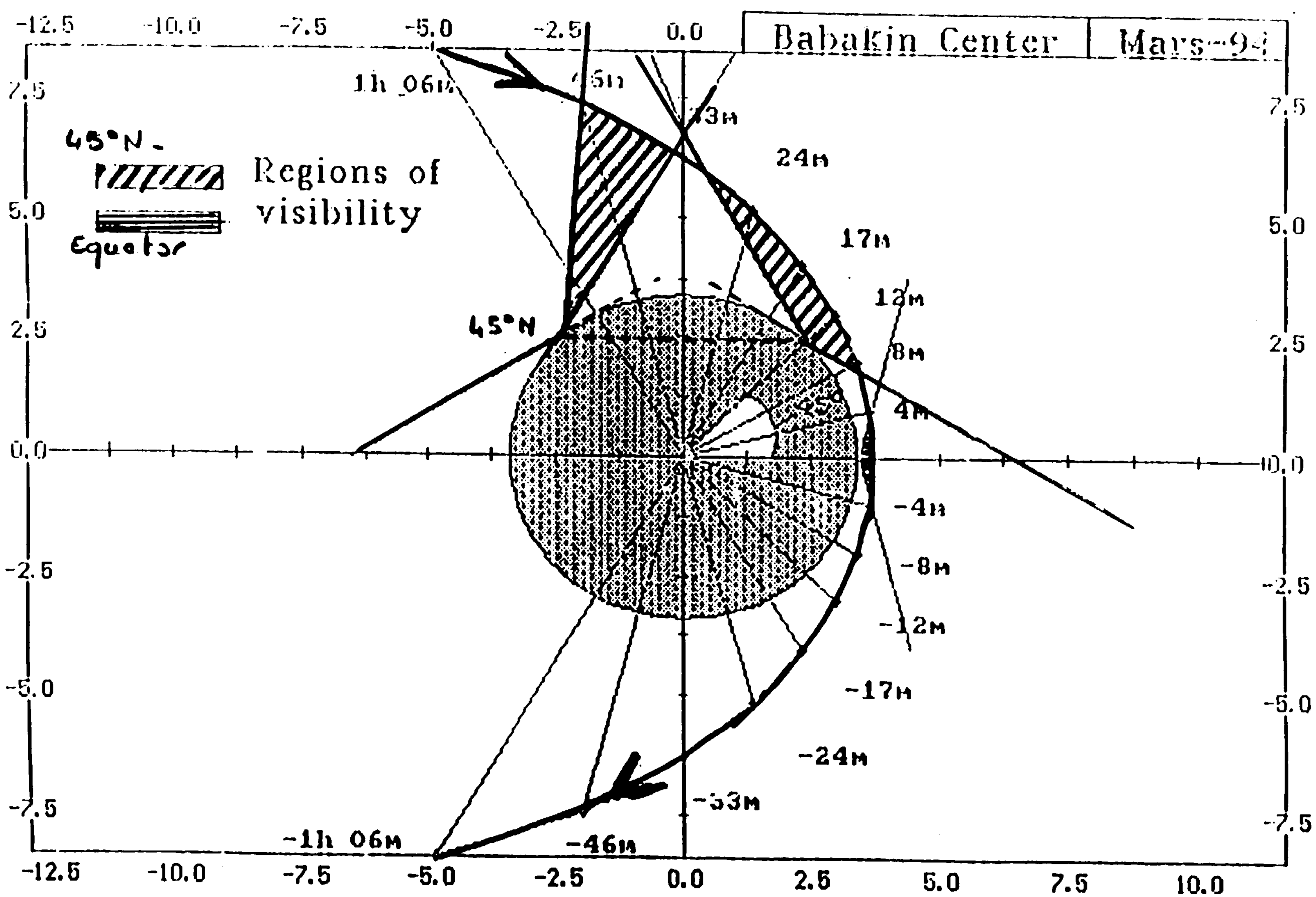
- *Figure 2: Trace au sol du centre optique de la caméra.*

K



- *Figure 3: Trace au sol du bord du champ de la caméra.*

Alamait



Babakin Center
Mars-94
Regions of visibility
45°N -
Equator
45°N
1h 06M
45M
33M
24M
17M
12M
8M
4M
-4M
-8M
-12M
-17M
-24M
-33M
-46M
-1h 06M

Liaisons

K

Mémoire : 32 Mbits

Rythme : 1 à 32 kbits/s
Mars 94 : 2 kbits/s
Mars Observer : 8 kbits/s

Arrivée Mars

Mise à poste
3 semaines

Orbite synchrone Mars
2 à 3 semaines

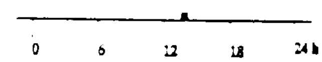
Orbite synchrone Terre

Visibilités Mars 94

(Début de mission)

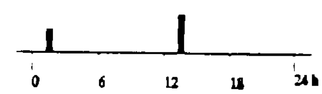
Mise à poste : pas de liaisons

Orbite synchrone Mars :

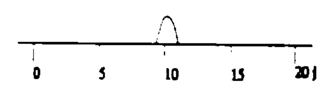


j = 0 deg N 1 visibilité/jour, durée 6 mn vers 14h locales
j = 45 deg N 2 visibilités/jour, durée 20 mn vers 14h et 12 mn vers 2h

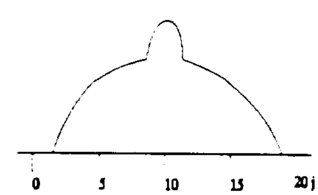
Orbite synchrone Terre :



j = 0 deg N cycle de 20 jours
- pdt 3 à 4 jours 1 visibilité/jour, durée jusqu'à 8 mn, vers 12h locales
- pdt 16 à 17 jours pas de visibilité

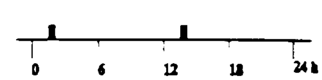


j = 45 deg N cycle de 20 jours
- pdt 2 à 3 jours pas de visibilité
- pdt 7 à 8 jours 1 visibilité/jour, durée jusqu'à 25 mn, vers 22h locales
- pdt 6 à 7 jours 2 visibilités/jour, durée totale jusqu'à 35 mn, vers 22h et 12h
- pdt 4 à 5 jours 1 visibilité/jour, durée jusqu'à 25 mn, vers 22h locales



Visibilités Mars Observer

Deux visibilités par jour, durée moyenne 9 mn vers 2h et 14h locales



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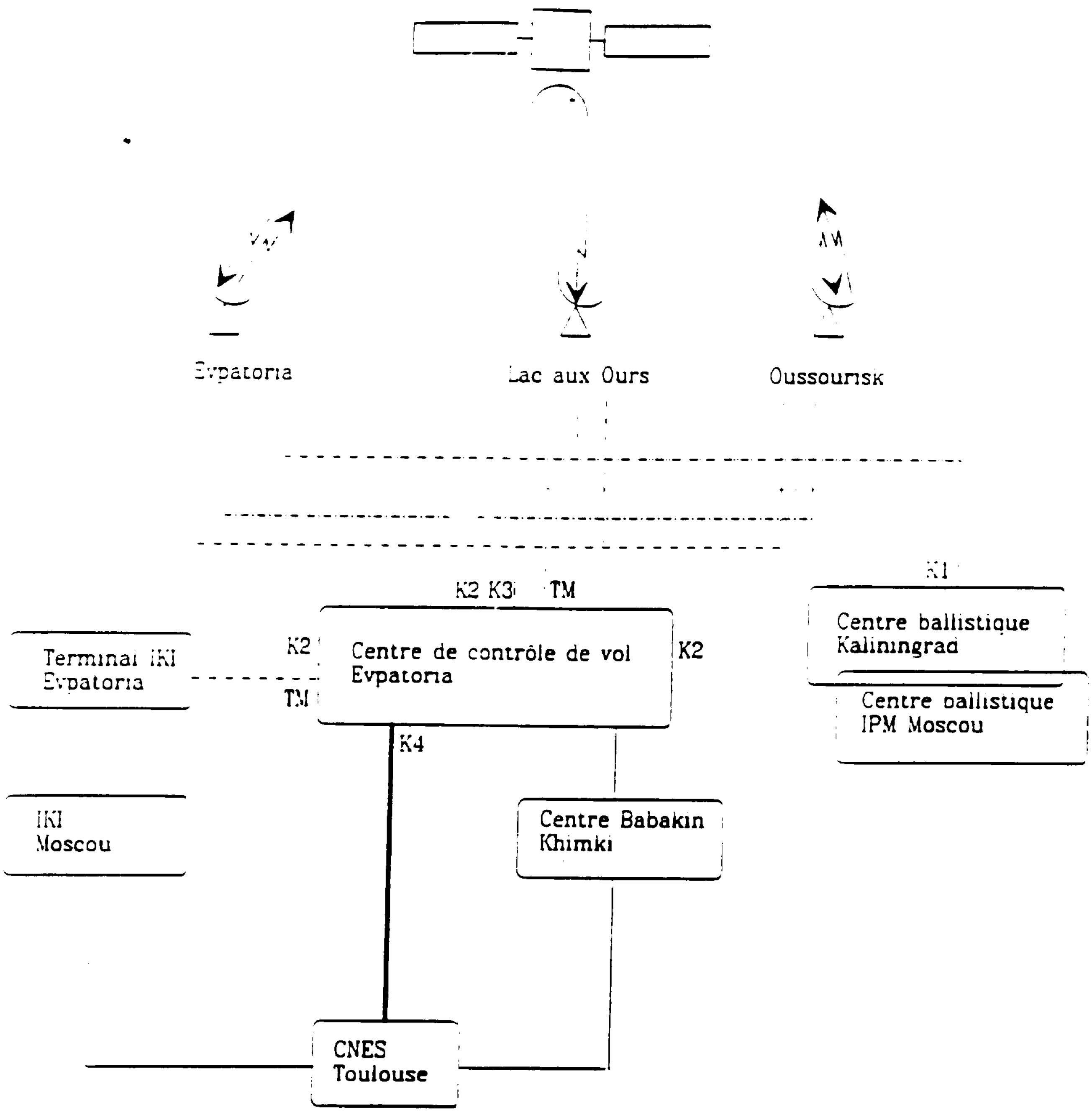
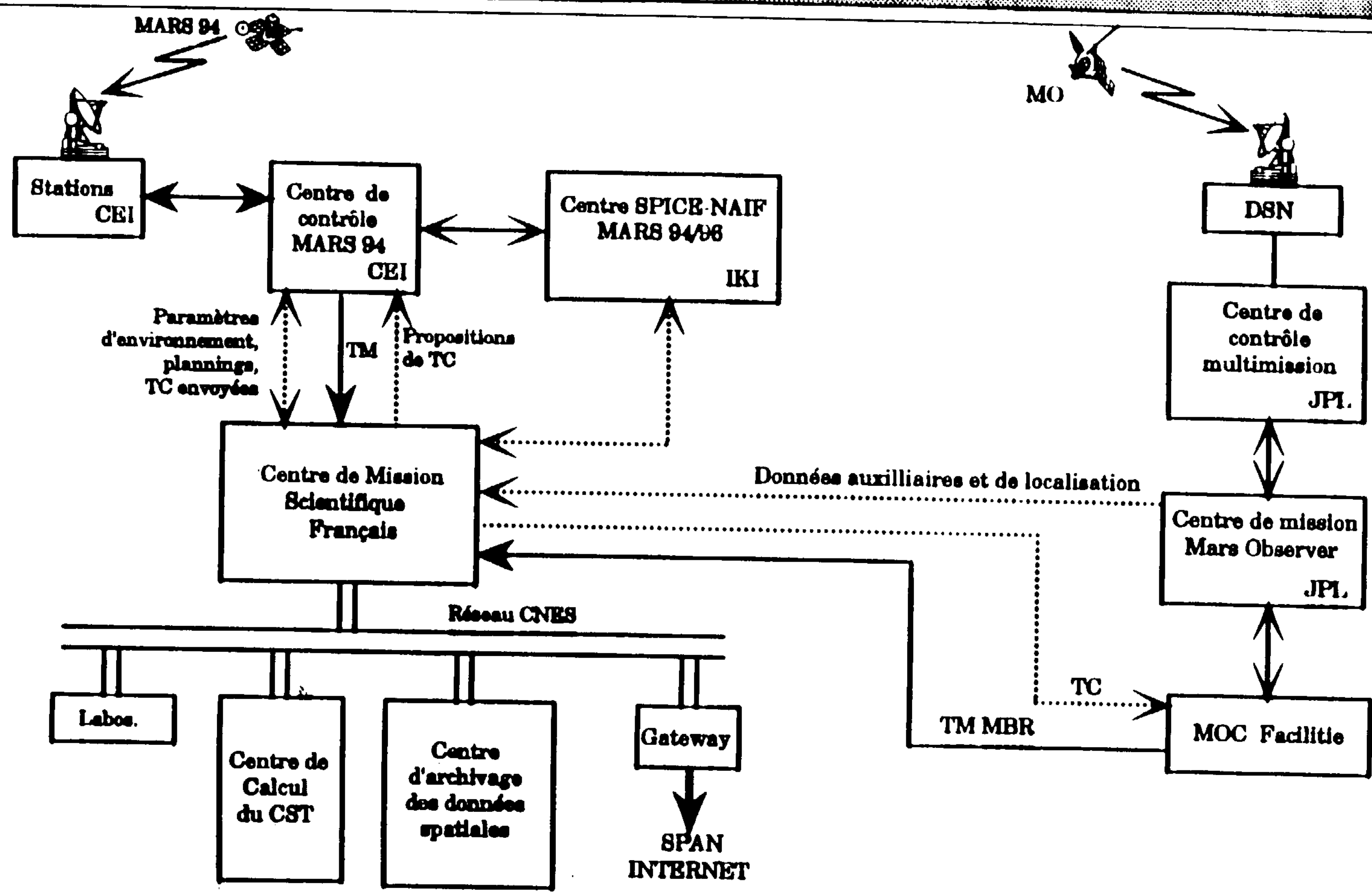
Segment sol sovietique



K1 : Informations balistiques et programmes de poursuite
K2 : Echanges d'informations pour la préparation des séances et les programmes de fonctionnement
K3 : Fichiers de commande (TC)
K4 : Liaisons avec les partenaires étrangers
TM : Télémesure scientifique et de servitude

MARS 94/96



Organisation Générale du Segment Sol

MESUR SDT Activities for F.Y. '92

- Establish characteristics, capabilities, and requirements of strawman payload instruments in much greater detail (about 2 instruments per meeting).
- Investigate orbital sounder: State minimum science requirements, examine possible instrument concepts, aid JPL in investigation of accommodation on spacecraft.
- Establish science requirements for a possible microrover.
- Establish strawman payload for a possible microrover.
- Investigate techniques for doing rock geochemistry/mineralogy remotely and make recommendations on inclusion in strawman payload.
- Modify existing network configuration and deployment timing to accommodate geochemistry, imaging, and entry science, and to maximize robustness to lander failures.
- Other tasks as requested by NASA Headquarters, JPL, and MarsSWG. *(The focus here has been MESUR Pathfinder.)*
- (Present membership: Squyres, Banerdt, Boynton, Carr, Des Marais, Duennebier, Golombek, Greeley, Haberle, Leovy, McSween, Seiff, Solomon, Zent)

Squyres
(1)

Topics at May 21-22 SDT Meeting

- MESUR Pathfinder
  - Under what conditions should it be flown?
  - What should be the science payload?
- Facility vs. PI instrumentation (focus on Pathfinder)
- Network configuration progress
- Seismology workshop report
- TA/EGA instrument status
- Marsnet status

MESUR Pathfinder

- Potential Benefits:
  - Provides an engineering model for the MESUR mission
  - Brings significant early funding to MESUR
  - Provides a test of new mission management approaches
  - Demonstrates commitment to MESUR to potential international partners
- Potential Drawbacks:
  - Does little of the science planned for MESUR
  - If done for no more than \$150M, it appears likely to be high-risk
  - If done with the usual level of risk, it appears likely to cost more than \$150M
  - Failure to meet both cost and success objectives would endanger both MESUR and Discovery seriously

MESUR Pathfinder (cont'd)

- Suggested approach:
  - Study intensively from now until October.
  - Apply conservative cost estimation procedures throughout study, and descope as necessary to stay within budget ("design to cost").
  - Go forward with it in October only if it meets clear acceptance criteria.
- Suggested acceptance criteria:
  - Must cost less than \$150M.
  - Must have high probability of meeting mission success criteria.
  - Must do enough science, and/or reduce the cost and risk of MESUR, and/or improve the science of MESUR enough to justify the cost.

Pathfinder Science Payload

- Atmospheric structure instrument (P, T, accel.)
  - Required for engineering data
  - P and T sensors can work after landing as well
- Panoramic surface imager
  - Required to meet mission success criteria
- Alpha-proton-x-ray spectrometer
  - Place on microrover if available
  - Measurement of soil is valuable, but value is probably lessened if Mars '94 succeeds
- Seismometer
  - Focus is characterization of seismic noise environment
  - Desirable to include a wind speed sensor
- Code X instrumentation
  - Define as soon as possible.

Facility vs. PI

- In general, PI approach is preferred.
- For instruments that are nearly ready to fly now (like APXS), facility approach does not appear warranted.
- For others, a facility approach might be warranted and could work, with the appropriate management structure and approach.
- If facility instruments are going to be developed for MESUR:
  - Form IDST's soon.
  - Constitute Pathfinder "pre-PSG" from IDST chairs, other instrument representatives, and a few "Mars generalists".
  - Release AO that provides for the selection of a *single* Pathfinder science team.

Other Issues

- We've found a 16-station network design that appears to meet all the basic needs of meteorology, seismology, and geochemistry.
- We still need 10 Mbit/station/day for the seismology experiment.
- TA/EGA instrumentation for MESUR requires substantial further development work and funding.
- Two concerns regarding Marsnet:
  - Single-probe vs. multi-probe carrier issue still unresolved.
  - MESUR and Marsnet payloads are nearly identical.

2)

CORNELL UNIVERSITY
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Space Sciences Building
Ithaca, New York 14853-0355

Steven W. Squyres
[607] 255-3508
NASAmail: ssquyres
FAX: [607] 255-9002

June 4, 1992

Dr. Carl Pilcher & Mr. Doug Broome
Code SL
NASA Headquarters
Washington, DC 20546

Dear Carl and Doug:

I was very pleased that both of you were able to attend the MESUR Science Definition Team meeting at JPL on May 21st and 22nd. Your presence sent a clear signal about the significance that Code SL attaches to the MESUR mission, and about the role of science in that mission. In this letter, I'd like to summarize to you the recommendations and findings that came from our discussions.

MESUR Pathfinder

This was, of course, the first meeting of the group since the real emergence of the MESUR Pathfinder mission concept. As you know, there has been some controversy within the planetary community over Pathfinder, with strong views expressed both in its favor and against it. We therefore tried to give the matter careful attention. We considered three issues associated with Pathfinder: the conditions under which it should be selected for development and flight, the payload it should carry if it flies, and the utility of a microrover on it.

Conditions for selection: At the beginning of the meeting, we heard both from Headquarters and JPL staff the arguments in favor of Pathfinder. Some of them may be summarized briefly as follows:

- It has the potential to provide an effective engineering model of the MESUR spacecraft and mission operations system, which can be a good way of reducing cost and schedule risk in a program.
- It could bring significant funding to the MESUR program much earlier than would be the case with just a '96 or '97 new start for the network.

L

- It would provide a test and, one hopes, a demonstration of new mission management principles aimed at reducing the cost of MESUR.
- It would demonstrate to potential international partners a commitment to MESUR that could help in the selling of collaborative Mars missions overseas.

Given some of the recent history of the planetary exploration program, the programmatic appeal of the mission is obvious. We understand that the Pathfinder concept has been reported to NASA's upper management and to the Congress, and that the response has been favorable. We clearly recognize the support that the mission has, and our discussions took place in that context.

Along with the potential benefits of Pathfinder, we also see some serious potential drawbacks:

- Pathfinder, by itself, can do very little of the science planned for MESUR.
- If the mission is done at an acceptable cost, it appears to us likely to involve considerable risk.
- If the mission is done at the usual level of risk, it appears to us likely to exceed the $150 million budget cap.
- Failure to meet both the stated cost and mission success objectives would, we believe, seriously endanger both MESUR and the rest of the Discovery program.
- It is not clear to us that lessons learned from Pathfinder can be carried over to MESUR well. Pathfinder's arrival at Mars is when the proof of entry, landing, and deployment systems will come, but is only a little over a year before the first MESUR launch. Moreover, it appears that cost and schedule constraints could force design compromises on Pathfinder that would be inappropriate for MESUR; this could either lessen the heritage from one mission to the other or force MESUR to be less capable than it should be.

Because of these concerns, it was not obvious to the group that the Pathfinder mission should go forward. However, because of the mission's present momentum and because some of our concerns could be proven to be unwarranted, we also feel that more work is in order before the final decision is made. Specifically, **we recommend that the period from now until October of this year be used to study the Pathfinder mission thoroughly. Conservative cost estimation procedures, devoid of wishful thinking, should be applied continuously throughout this process. If the costs begin to look likely to exceed $150 million, the mission should be reduced in scope to fit the budget, and the SDT should participate in the descoping process. In October, if the mission is not found to meet an appropriate set of acceptance criteria, it should be rejected.**

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The acceptance criteria that we recommend for Pathfinder are these: (1) It should be shown with confidence to cost no more than $150 million. (2) It should be shown to have a high probability of meeting its technical success criteria. (3) It should be shown capable of doing significant science, and/or reducing the cost and risk of MESUR, and/or improving the science return of MESUR enough to justify the $150 million cost. Doing significant science, in this context, would probably mean making at least one scientific measurement at Mars that is planned for MESUR and that has never been made successfully in the past. (In fact, some members of the group felt that Pathfinder should be held to this scientific standard regardless of what it can do for MESUR.) If and only if all three criteria listed above are met in October, we stand ready to support Pathfinder.

<u>Payload</u>: As noted above, Pathfinder can do little of the science planned for MESUR. It can, however, do some valuable science if it carries the right instrumentation. In a letter to Carl dated April 8th, we reported some preliminary recommendations on the science payload for Pathfinder. The instruments we recommended at that time were an atmospheric structure instrument (ASI), a panoramic surface imager, an alpha-proton-x-ray spectrometer (APXS), and a seismometer. We further noted that the pressure and temperature sensors of the ASI could be made to function on the surface as well, providing a capability to make long-term meteorological measurements.

After careful consideration, we still feel that our previous recommendation is fundamentally the correct payload for Pathfinder. However, we also recognize the substantial cost pressure on Pathfinder, and the fact that it is, at heart, an engineering demonstration mission. We therefore considered each instrument carefully, and offer some thoughts below on what each could contribute to the mission objectives. These contributions are among the things that must be considered in the future if Pathfinder goes forward but it becomes necessary to descope the mission.

The atmospheric structure instrument and the imager stand apart from the others on our list, in that both are needed to meet Pathfinder's mission success objectives as they are now defined. **We therefore assume both the ASI and the imager to be required instruments for Pathfinder.** We noted previously that a MESUR ASI consisting of a pressure sensor, a temperature sensor, and an accelerometer could provide important atmospheric data for a latitude and/or season not previously explored. We also noted that a panoramic surface imager would yield new data about geologic processes operating at a site different from any explored to date. Both are worthwhile scientific objectives, independent of any engineering or public-interest role that these instruments might play. We do not expect the ASI desired for science to be substantially more difficult to develop than one required for engineering purposes. A camera designed for science could be of substantially higher quality (*e.g.*, higher resolution, better spectral coverage, higher signal/noise) than one required for engineering purposes, however. We would, of course, advocate flying the most capable camera feasible.

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The APXS is, for MESUR, one of the prime candidate instruments for a microrover. If it is possible to include a microrover on Pathfinder, it would clearly make sense to put an APXS on it. However, we stress that even if no microrover is flown on Pathfinder, there is considerable scientific value in flying an APXS that would measure soil chemistry. The APXS technique has never been used on martian soil, and would provide chemical information complementary to any that exists or that is expected from the Mars Observer mission. Because of this, and because of the very advanced state of development of this instrument, **we urge that every effort be made to include an APXS on Pathfinder, independent of the presence of a microrover.** The only counterargument that we note is that APXS's for measurement of soil chemistry are planned for both the penetrators and small stations on Mars '94. If these measurements are made successfully, then the importance of another APXS measurement of material other than rock is diminished significantly.

The most difficult instrument issue for Pathfinder deals with the seismometer. Our previous recommendation was based on the assumption that Pathfinder could operate on the surface for something like one Mars year. It now appears that this assumption was incorrect, and that a period of weeks or even days may be more likely. **A seismology experiment is still very important, but this importance is lessened somewhat by a shorter experiment duration.** We previously advocated this experiment based on three things that it could do: (1) characterize the ambient seismic noise, (2) characterize seismic signals on Mars, and (3) allow a test of the instrument deployment mechanism. Objective (3) is still valid and important. Objective (2) is much more difficult with a single lander than it would be with two, and the chances of accomplishing it decrease in direct proportion to the observation time. With only a few weeks of data from one station, the chances of characterizing a seismic signal with confidence cannot be considered large. Objective (1) could be met well with data from an experiment with a duration as short as a day, and still has high priority. In fact, adequate characterization of the seismic noise environment has the potential to ease some of the other requirements currently driving the design of the MESUR seismometer experiment.

One obvious but important point about a Pathfinder seismology experiment is that it would be seriously hampered by a very short-duration mission. Even if comparatively low-reliability parts and assembly techniques are used, there is a significant chance that an appropriately-designed lander could operate on the surface for a period of months or years, rather than days or weeks. Such a situation clearly would benefit the meteorological science as well. **We therefore urge strongly against making decisions (such as selecting batteries only for power) that would clearly preclude long-duration operation of Pathfinder.**

Carl, in your letter of April 8th, you asked us whether a Pathfinder seismology experiment would have to be complemented by a wind measurement in order to make useful measurements. We did not consider cross-instrument synergy of this sort in our first cut at the payload, but at this meeting we gave the issue careful consideration. Wind is expected to be one of the most important sources of seismic noise on Mars, and **we conclude that a wind measurement made in conjunction with a seismic experiment aimed at characterizing the seismic noise environment would be useful.** The measurement could be rather simple, with a small expected data volume. Wind direction is of less importance for this purpose than wind speed.

Finally, in our previous letter, we mentioned the scientific value of another full Mars year of pressure and temperature data taken at a surface site, and advocated that such measurements be made on Pathfinder on this basis. With our new understanding of the likely duration of Pathfinder's operation on the surface, this argument no longer appears valid. However, we still believe that it should be possible to make these measurements with essentially no modification to the ASI experiment. If detailed analysis shows this belief to be correct, then we feel that the measurements should be made, if only as a test of the technique for use on MESUR.

Microrover: We also gave consideration to the issue of a microrover for Pathfinder. In previous letters, we have made the point that a microrover appears to many of us to be the only way of ensuring that the MESUR APXS instrument can meet its most important scientific objectives. **We therefore strongly advocate the inclusion on MESUR of a simple microrover that can, at a minimum, deploy the APXS to a rock.** We have also voiced the caution that addition of capabilities beyond this to the MESUR microrover must ultimately come at some cost, and that the value of these additional capabilities should be weighed against other science that could be done for the same cost.

We now understand that NASA's Code R may be interested in developing a microrover for Pathfinder. We greet this prospect with enthusiasm. Moreover, we note that the resources available for this development may be nicely in line with the minimimum requirement — deployment of the APXS to a rock — that we envision. We continue to have concerns about the costs of microrover accommodation on a tightly constrained mission like Pathfinder, and we would not advocate a microrover for this mission if it were to become a significant drain on Code SL resources. However, if Code R could develop a simple microrover that would enable both the Pathfinder and MESUR APXS's to obtain the data on rock chemistry that we desire, it would be a contribution of great scientific importance.

Facility vs. PI instrumentation

Another major topic of our meeting was the issue of facility vs. PI instrumentation for both Pathfinder and MESUR. We devoted the bulk of our discussion to Pathfinder, and postponed a recommendation for MESUR to a future meeting. Our discussion began with a broad review of the history of facility and PI instrumentation on planetary flight projects, drawing on the considerable experience of the people in the room. The consensus was that the PI approach tends to produce good instruments most consistently, but that the facility approach can work well under the proper circumstances. Our most important observation was that **facility instrumentation must be developed under a management structure and policy that allow very close interaction between the science team and the instrument builders.** Bad facility instrument experiences have consistently been ones where communication was poor between the scientists who generated requirements and the instrument builders charged with meeting them. A simple management structure, with communicative, responsive people in the key jobs, is essential for success under the facility approach.

An important point in considering the management structure and division of responsibilities for a facility instrument is that it is the scientists whose careers ultimately depend most on the quality of the data from a instrument. For this reason, if serious problems occur during the development of a facility instrument, the scientists need to have the authority do what is necessary to make things right. This need not cost money (in fact, it may ultimately save money), but in some cases it may mean having the authority to see that the right people are put in the right jobs, so that communication and responsiveness are adequate.

While we favor the PI approach in principle, we recognize that schedule pressures for Pathfinder may make a good case for development of facility instrumentation for that mission if it is to be flown. **We therefore accept the view that most Code SL instruments on Pathfinder should be developed and provided by NASA as facilities. For each Pathfinder facility instrument, we recommend that NASA appoint an Instrument Definition Science Team (IDST) as soon as possible.** These groups should be small, and composed of individuals willing to devote considerable effort to the task. The job of the IDST's would be to provide detailed guidance to NASA on the performance and design of each of the prospective Pathfinder instruments.

A possible exception to our acceptance of the facility approach for Pathfinder is the case where an instrument is already going to be available, essentially "off the shelf", in time to meet the Pathfinder schedule. If this is the case, the arguments for making an instrument a facility do not appear strong enough to justify the facility approach over the PI approach. Of the instruments we have recommended for Pathfinder, the one most likely to meet this condition is the APXS, which flew recently on the Phobos mission and will fly again on Mars '94.

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We feel that if Pathfinder is to go forward, the Pathfinder project office should receive thoughtful and timely advice from a group of qualified scientists. Therefore, **we recommend that a pre-project science group be formed for Pathfinder as soon as possible.** This group should be chaired by the JPL pre-project scientist, and should include each of the IDST chairs. Scientists associated with any prospective PI instruments should be part of it as well. It probably should also include one or two other scientists who can be considered "Mars generalists", in that they would bring to the group a broad overview of scientific issues to be addressed at Mars. Finally, we expect that Code X should be represented on this group, in whatever manner is deemed appropriate. We emphasize that Code X objectives should be integrated into the science planning process as soon as possible.

If Pathfinder were to be taken to flight status, then the IDST's would guide instrument development and the pre-PSG would provide science guidance to JPL during the pre-AO period. As soon as an AO was released, these appointed groups would be disbanded. Because Pathfinder would be a highly constrained mission, we do not recommend the selection of separate flight teams for each Pathfinder instrument. Instead, **we recommend that any Pathfinder AO process provide for selection of a single science team and a single team leader.** This approach would eliminate a layer of management on the science side of the project, establishing direct communication between all selected investigators and the project. This team would have responsibility for continued instrument development, as well as for analysis of the data. Before arrival at Mars, **an original team of this sort should be augmented by selection of additional investigators who would also participate in analysis of the data.** Funds for such additional investigators should be planned for from the start, and should be protected throughout the life of the project.

There would, of course, be a gap in time between when the pre-PSG was disbanded and when the Pathfinder flight team was selected under this scenario. During this time the Pathfinder project could receive scientific guidance from the scientists on their own staff, and we have confidence in this process. Nevertheless, we hope that Headquarters would rise to the challenge of making and announcing such a selection as quickly as possible.

There are several other points that we would like to make regarding facility vs. PI instrumentation. First, we see the issue for Pathfinder as separate from that for MESUR, and we note that it may make sense to have MESUR include mainly PI instrumentation. Second, we stress that designation of an instrument as a facility need not mean that it should be developed at JPL. In keeping with the streamlined management approach suggested above, we feel that it is imperative that all facility instruments on Pathfinder be managed by JPL, rather than by some other NASA center. However, the instruments should be built where they can be built best, whether at JPL, by industry, by a university, or by an international partner. Finally, while we have postponed discussion of instrumentation for MESUR, we recommend that a careful look be taken, as soon as possible, at the "plug-in/must-fly" instrument concept being advocated for MESUR, since we have significant doubts as to whether such an approach will really be feasible without undue cost.

TA/EGA instrumentation

In our continuing look at the MESUR strawman payload, we concentrated at this meeting on the TA/EGA instrument. The TA/EGA is an important instrument for MESUR, since it is the only one on the strawman payload that addresses the poorly-understood area of martian mineralogy. Despite its importance, the state of development of the instrument is primitive compared to what will actually be required for flight. Thermal analysis and evolved gas analysis are mature techniques in laboratory settings. However, small, flight-qualified instruments do not exist. One major area that needs work is miniaturization. Existing differential scanning calorimeters (DSC's) are far too large and heavy to be flown on MESUR. A concept for a miniaturized DSC was developed for CRAF, but was never taken beyond the conceptual stage. Small gas chromatography columns exist, but key mechanical components such as flight-qualified valves require significant further miniaturization work. Improvements in the dynamic range and sensitivity of the metastable ionization detectors typically used in GC's are necessary in order to provide adequate results for a very small instrument and sample mass. The TA/EGA is the only instrument envisioned for MESUR that requires true acquisition of a sample, and even a good conceptual design for a sampling mechanism is lacking.

Given its complexity, we expect that the TA/EGA is going to be the most expensive instrument on MESUR. Because of this, and because of the instrument's importance to the mission, **we stress that substantial investment in the development of this instrument is necessary, and that this investment should be made soon.**

Seismology experiment

Sean Solomon reported to us on a workshop that was held at MIT to investigate in detail some of the requirements associated with the MESUR seismology experiment. A detailed report of this workshop will be included in the notes of our meeting. The main focus of the workshop was the uplink and data rate requirements of the MESUR seismology experiment. As we have noted previously, the basic data requirement for this experiment is 100 Mbit/station/day. This can be reduced significantly, but only at the expense of instrument complexity and uplink command volume. The conclusion of the workshop was that a reduction of only a factor of ten is possible before there is an unacceptable loss of science. Therefore, **we reiterate our earlier conclusion that a data rate of 10 Mbit/station/day is required for the MESUR seismology experiment.**

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Network configuration

Bob Haberle reported on an effort that he led to further refine our design of a network that meets all of the MESUR mission's science requirements. After a previous meeting, we reported to you that we had found a 16-station network that meets the needs of seismology and atmospheric science. After some effort, we now have found a 16-station network that appears to meet the needs of the other MESUR science disciplines as well. As we have stressed previously, this is not an effort to select the actual MESUR landing sites; it is an effort to show that an adequate network design exists. The next step in this process, which we have now taken, is to hand our design over to the MESUR mission analysis group at JPL. At our next meeting in August, they will report back to us on the feasibility of our design, and on any changes that are necessary to make it conform to mission constraints that we have not yet considered.

Marsnet

We finished our meeting with a presentation from Augustin Chicarro about the status of the Marsnet mission study. We note with some concern that the single-probe carrier vs. multi-probe carrier issue is still considered open. It seems clear that this issue must be put to rest quickly and in a manner satisfactory to both sides if real progress on coordinated MESUR and Marsnet studies is to continue to take place. We also note that the issue of science complementarity has not yet been addressed with any success. In fact, despite considerable efforts on both sides, the present MESUR and Marsnet science payloads are nearly identical. While this is a comforting validation of the strawman payload selection process, we remain concerned that both Marsnet and MESUR must compete with other missions during the new start process, and that each mission's competitive position could be weakened by a lack of complementarity with the other. A decision as to whether to change the Marsnet model payload of course rests with ESA, but we stand ready to suggest changes to MESUR should ESA show a willingness to change Marsnet.

I hope that the recommendations we have made here are helpful. As always, please contact me if you would like any clarification or amplification of any of these points. Once again, I'm very glad that both of you were able to attend our meeting, and I hope

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that you'll be able to join us again at future meetings.

Best wishes,

Steve Squyres
Chair, MESUR SDT

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